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IN MEMORIAM.

Not only in Ceylon, but throughout the planting countries of the Eastern Tropics, the news of the death of Montague Kelway Bamber, as the result of a motor accident, stunned all with an overwhelming feeling of immediate personal loss. It seemed beyond belief that such an outstanding personality had so abruptly ended.

After a distinguished studentship at the Royal Agricultural College, Cirencester, Bamber came East to a Government Research Institute in Northern India, and subsequently, in 1891, took up the post of Chemist to the Indian Tea Association. While working in that capacity he published, in 1893, a book, *The Chemistry and Agriculture of Tea*, one of the first text-books relating to the tea industry. About 1898, he came to Ceylon, and in that year was engaged by the Ceylon Planters' Association to investigate the growth and manufacture of tea in this country, particularly with regard to the possible connection between soil and quality. His interest in this subject was never lost, and the last enquiry which he undertook for the Department of Agriculture dealt with this elusive problem. The results of his earlier work on this were published in 1900 as a Report on Ceylon Tea Soils.

On the termination of his engagement with the Ceylon Planters' Association, Bamber established a laboratory in Colombo, and took up the work of an analytical chemist, being at the same time retained by Government as Consulting Agricultural Chemist. Here he was joined shortly afterwards by Mr. A. Bruce, and, apart from the private work of the firm, there has issued from that laboratory an extraordinarily large amount of valuable information, both chemical and agricultural, relating to the products of this country.

In 1904, Bamber was selected, together with the late Mr. A. C. Kingsford, by the Planters' Association, to visit Java, Formosa, and Japan, in order to investigate the conditions of tea cultivation and manufacture in these countries, a report on which was published in book-form in 1907.

On the formation of the Ceylon Agricultural Society, Bamber took a leading part in its activities, and his information and services were always at its disposal. On several occasions he acted as Secretary, and he had the somewhat amusing experience, considering his position at the time, of being offered the post of permanent secretary. In his connection with the Agricultural Society, he investigated numerous minor products, and was especially interested in the possible utilisation of jungle products as a means of finding employment for the inhabitants of the more remote districts of the country.

Though Bamber originally came to Ceylon as an expert on tea, his interests soon broadened to cover all the major tropical crops. The gradual development of the rubber industry presented an opportunity which was not neglected, and his pioneer investigations on this head placed him in the foremost rank of rubber specialists. His advice was widely sought in other countries, and his sphere of labour was extended to South India, Malaya, Java, and Sumatra, where he became almost as well-known as in Ceylon, while no Exhibition or Congress dealing with tropical products was complete without him.

To those who knew Bamber in his busiest time, say from 1907 to 1912, his most remarkable characteristic was his astonishing vitality. His work as Agricultural Chemist to Government and the Agricultural Society was combined with that of visiting scientific adviser to a large number of estates in Ceylon, Malaya, India, etc., and even the mere physical exertion entailed in travelling would have exhausted most people. Yet there seemed no limit to the amount of work he could undertake.

Mr. Bamber was held in high esteem by successive Governors, notably by Sir Henry Blake and Sir Henry McCallum. It is an open secret that he was offered the post of first Director of Agriculture in Ceylon, but that he was compelled to decline it owing to the financial sacrifices which the acceptance of an official position would have entailed.

Bamber's activities were so varied that it is difficult to select from among them those by which he will be best remembered. Perhaps his influence on the manuring and cultivation of tea, and especially the introduction of the system of green manuring, will rank among his most notable achievements.

But we have so far omitted all reference to the characteristic for which he will be chiefly remembered. Even if we forget all the scientific work which Bamber has done for the planting industry, it is impossible for any one who was acquainted with him to forget his charming courtesy, his unfailing good humour, and his willing assistance at all times. The feeling of all is that we have lost, not only a fellow worker, but a friend.

RUBBER

MANURIAL EXPERIMENTS ON HEVEA.

Extensive manurial experiments on *Hevea* have been carried out in Sumatra by the Hollandsch-Amerikaansche Plantage Maatschappij, and an account of these has recently been published by Mr. J. Grantham in the *Archief voor de Rubbercultuur*, VIII, No. 8 (August, 1924). The following summary has been compiled from that account.

In the district where the estates on which the experiments were conducted are situated, there are two sharply contrasted types of soil, a red soil and a whitish soil. The red soil is relatively uniform and of an open loose texture.

The whitish soil area has three main types of soil, *viz.*, a somewhat brownish loam of good texture, a white sandy loam, and a white clay which in some places is very hard and of a cementing nature, *i.e.*, after being broken up by cultivation and then exposed to rains it forms a hard, impermeable, cement-like mass on subsequent drying. The subsoil of this area is a white or bluish grey, hard, impermeable soil of the cementing type.

Rubber grows well on the red soil. On the white soils, growth is excellent up to about five or six years, after which deterioration is liable to begin.

FIRST NITRATE MANURING EXPERIMENT.

This experiment was begun with the idea of testing whether an application of sodium nitrate during the wintering period would diminish the fall in yield which takes place normally at that time.

Twelve fields of five acres each were selected on white loam soil. The trees were six years old. Fields 2, 6 and 10, were given 5 cwt. of sodium nitrate per acre, and fields 4, 8 and 12 were taken as controls. The manure was applied once, in February, 1918, the surface soil being lightly hoed over. The intervening fields 1, 3, 5, 7, 9 and 11 were regarded as neutral plots, as their edges might be influenced by the manuring of 2, 6, and 10.

The results, from February, 1918 to April, 1921, are given in weight of latex. The manured plots gave a total of 19 per cent. over the control plots, while the yield of the neutral plots was intermediate. "The percentage difference necessary for significance probably exceeded 15 per cent."

Six weeks after the application of the manure, the foliage of the manured plots became a very dark green as compared with the light yellow green of the controls. This difference persisted until the next wintering period, and during that period the treated plots appeared to winter later than the others. The maximum increased yield of the manured plots over the controls occurred at that time.

No appreciable increase in yield occurred until about eight months after the application of the manure, and the hope of a specific stimulation of yield during wintering was not realised.

Taking the lowest control as 100, the three controls gave 100, 110, and 117, while the three manured plots gave 127, 131, and 132. It is remarkable that in the first year the manured plots were only about 12 per cent. better than the controls ; in the second year they were 22 per cent. better ; in the third year 20 per cent. better ; and in the four months of the fourth year, 22 per cent.

The average yield per tree on the best manured plot was 26½ lb. of latex in 3 years 2 months. Supposing the rubber content was 3 lb. to the gallon, that gives an average of a little more than 2½ lb. of rubber per tree per year. The worst control gave 20 lb. of latex. On the same supposition, that is nearly 2 lb. of rubber per tree per year.

SECOND NITRATE MANURING EXPERIMENT.

The previous results led to the initiation of another experiment on white loam soil in February, 1919. These were planned so that a difference exceeding 9·5 per cent. could be regarded as significant.

30 acres of rubber, eight years old, was divided into 40 three-quarter acre blocks, each containing 90 trees. These blocks were divided into five series, each receiving a different treatment, there being thus eight plots subject to each treatment, scattered chess-board fashion. The original treatments were as follows :—

Series A. Control.
Series B. 5 cwt. sodium nitrate per acre.
Series C. 3 cwt. sodium nitrate per acre.
Series D. 1 cwt. sodium nitrate per acre.
Series E. Second control.

The plots were separated by drains two feet deep. The trees were tapped daily on one-third circumference, originally consuming 1½ inches per month with a four years' renewal, but in 1920, this was changed to 1¾ inches per month with a six years' renewal. Presuming that three inches was left at the base, the tapping cut started at a height of 27 inches at first, and was subsequently moved up to 45 inches.

The original manuring scheme was subsequently modified, and the actual treatment of the plots is summarised below.

Series A. Control

Series B. 5 cwt. sodium nitrate per acre in February, 1919 ; nothing subsequently.

Series C. 3 cwt. sodium nitrate per acre in February, 1919 ; 5 cwt. each subsequent year.

Series D. 1 cwt. sodium nitrate per acre in February, 1919.
5 cwt. superphosphate per acre in April, 1920.
5 cwt. calcium nitrate per acre in March, 1921.
Nothing in 1922.
5 lb. calcium nitrate per tree in 1923.

Series E. Nothing in 1919.
5 cwt. ammonium sulphate per acre in March, 1920.
Nothing in 1921.
5 cwt. ammonium sulphate per acre in March, 1922.
Nothing in 1923.

The actual yields per acre from March, 1919, to February, 1924, were as follows:—

	1919-20	1920-21	1921-22	1922-23	1923-24	Average per acre.
A.	279	310	180	298	171	248
B.	340	398	281	401	257	355
C.	321	393	354	533	422	404
D.	302	325	237	382	251	300
E.	292	353	283	465	352	349

The variations in yield from year to year are in part due to the differences in the height of the tapping cut ; for example, in the third year the diminution is due to a high tapping cut, and similarly in the fifth year.

The percentage ratios, taking the control plots as 100, are:—

	1919-20	1920-21	1921-22	1922-23	1923-24	Total
A.	100	100	100	100	100	100
B.	121·7	128·1	155·7	134·6	149·9	135
C.	115·0	126·5	196·1	179·0	246·4	163
D.	108·2	104·8	134·4	128·1	146·8	121
E.	104·7	113·8	156·9	155·9	205·9	141

Thus each series of plots responded to nitrogenous manuring. Series B, manured once with sodium nitrate, gave 35 per cent. more than the control series. Series C, manured annually with sodium nitrate, gave 63 per cent. more than the controls. Series D gave no result with superphosphate, but an increase with calcium nitrate. Series E, manured in alternate years with ammonium sulphate gave 41 per cent. more than the controls.

The explanation of these results would appear to be found in the controls. The trees were eight years old at the beginning of the experiment, and the average yield of the unmanured trees was 248 lb. per acre; that is, trees 8-13 years old, tapped daily on one-third circumference, yielded 2 lb. per tree per annum. Obviously there was something abnormal about the control plots, and that, as recorded already, is that rubber on this soil begins to deteriorate after six or eight years.

OTHER MANURIAL EXPERIMENTS.

Other manurial experiments were begun in 1918 to test the response of the various soils to lime, nitrogen, phosphate, and potash. The manures employed were those available at the time, *viz.*, potassium chloride, basic

slag (Thomas phosphate), and sodium nitrate. Four sets of experiments were carried out on different estates, in each case with either five or six plots under each treatment. The unit plot was 100 trees, or in one instance 96 trees. The trees were tapped on one-third circumference daily. The age of the trees is not stated.

The treatment of the different series was as follows:—

Series A. Nitrate of soda, 300 lb.; potassium chloride, 150 lb.; basic slag, 300 lb.

Series B. Nitrate of soda, 300 lb.; potassium chloride, 150 lb.

Series C. Controls

Series D. Nitrate of soda, 300 lb.; basic slag, 300 lb.

Series E. Basic slag, 300 lb.; potassium chloride, 150 lb.

Series F. No manure in 1918; *Mimosa* planted, January, 1919.

Series G. Lime, 2,000 lb.

Series H. Lime, 2,000 lb.; nitrate of soda, 300 lb.; potassium chloride, 150 lb; basic slag, 300 lb,

Series K. Controls.

Plots A to F were in each case in a different group from plots G to K. Consequently the results of the two groups are given separately. In the following summary, N stands for sodium nitrate, P for basic slag, and K for potassium chloride. The significant difference is 11 per cent.

EXPERIMENT 1, ON BROWNISH LOAM.

The manures were applied in October, 1918. *Mimosa* was sown on the F plots in January, 1919, and was allowed to stand. The results for the first 15 months are given as dry rubber per 5 acres (600 trees) and for the next 14 months as weight of latex per 5 acres.

		Dry rubber lb. Oct. 1918-Dec. 1919	Percentage ratio	Latex lb. Jan. 1920-Feb. 1921	Percentage ratio
C.	Control	1,960	100	5,506	100
A.	N.P.K.	1,962	100·3	5,779	104·8
B.	N.K.	1,988	101·6	5,924	107·5
D.	N.P.	1,895	96·8	5,544	100·6
E.	P.K.	1,796	91·5	5,164	93·8
F.	Mimosa	1,826	90·2	5,498	99·8
K.	Control	1,735	100	4,822	100
G.	Lime	1,627	93·8	4,465	92·6
H.	Lime. N.P.K.	1,829	105·3	4,862	100·7

In this experiment no significant difference was obtained by manuring, and no effect on the appearance of the trees was noticed.

EXPERIMENT 2, ON RED SOIL.

The manures were applied in September, 1918, and the experiment was continued to the end of December, 1919. Series F., *Mimosa*, was not included. The yields are given as weight of rubber per 5 acres for the sixteen months.

		Yield in lb.	Percentage ratio
C.	Control	2,869	100
A.	N.P.K.	2,849	99·3
B.	N.K.	2,630	91·7
D.	N.P.	2,842	99·1
E.	P.K.	2,851	99·4
K.	Control	2,858	100
G.	Lime	2,735	95·7
H.	Lime. N.P.K.	2,609	91·3

In this experiment also, no significant difference was obtained by manuring, and there was no effect on the appearance of the trees.

EXPERIMENT 3, ON WHITE LOAM.

The manures were applied in August, 1918. The F series of plots were planted in January, 1919, with *Mimosa*, which was allowed to stand. The experiments were continued to the end of December, 1919. The yields for the 16 months, September, 1918, to December, 1919, are given as weight of rubber per 5 acres.

		Yield in lb.	Percentage ratio
C.	Control	1,964	100
A.	N. P. K.	2,008	102·3
B.	N. K.	2,093	106·5
D.	N. P.	2,150	109·6
E.	P. K.	2,050	104·4
F.	Mimosa	2,076	105·7
K.	Control	2,305	100
G.	Lime	2,204	95·6
H.	Lime. N. P. K.	2,327	101

Here again there is no significant difference in yield, and no appreciable difference in appearance of the trees was noted.

EXPERIMENT 4, ON HARD WHITE CEMENTING SOIL.

The manures were applied in September, 1918. On plot F, *Mimosa* was sown in January, 1919, and was changkolled in after a year and then

allowed to regenerate. The experiment was continued until June, 1921. As before, the yields are given as weight of rubber per 5 acres for the whole period, 2 years 10 months.

		Yield in lb.	Percentage ratio
C.	Control.	3,101	100
A.	N. P. K.	3,597	115·9
B.	N. K.	3,605	116·2
D.	N. P.	3,204	103·3
E.	P. K.	3,205	97·5
F.	Mimosa	3,907	99·6
K.	Control	2,345	100
G.	Lime	2,436	103·8
H.	Lime. N.P.K.	2,470	105·3

In this experiment, which was on the poorest soil, a decided effect was noted on the density and colour of the foliage in 1919, *i.e.*, after the first wintering subsequent to the application of the manures, on all plots which had received sodium nitrate. There is also a significant increase in yield in the A plots, which received sodium nitrate, potassium chloride and basic slag, and the B plots, which received sodium nitrate and potassium chloride. It is, however, difficult to give any interpretation of these results. From the results of the A and B plots, it would be deduced that the basic slag had no effect. But the combination of nitrate of soda and basic slag on the D plot does not give any increased yield, nor does the combination of potassium chloride and basic slag on the E plots. An increased yield is only obtained when nitrate of soda and potassium chloride are used together. The increased yields in this experiment are much inferior to those in the second nitrate manuring experiment.

It is to be noted that favourable results have been obtained only by the use of sodium nitrate, ammonium sulphate and calcium nitrate on a particular and exceptional type of soil, on which the trees suffer from nitrogen starvation. On ordinary red soils, sodium nitrate had no effect. With the exception stated, the results of the experiments agree with all others which have been recorded, *viz.*, that no increase in yield is obtained by manuring.

The following summary is quoted from the original paper.

SUMMARY.

(1) Experiments were carried out on the use of artificial manure on the soils of the H.A.P.M., *viz.*, the red liparite tuff sedentary soil and the various types of white alluvial soil.

(2) The white soils responded remarkably to the application of sodium nitrate, calcium nitrate and ammonium sulphate, and the typical deterioration characteristic of the older rubber on these soils was arrested. By repeated applications, the trees were improved until they equalled the trees on the good red soil in yield and appearance. The effect on the bark

renewal was also pronounced and to this is probably to be attributed the fact that a single application produces a more prolonged effect on yield than on appearance.

Sodium nitrate gave no effect on the red soil.

(3) The use of basic slag (Thomas phosphate), potassium chloride and lime was without effect on the white soil or on the red soil. Superphosphate was actually harmful, probably owing to its acidity.

(4) Green manuring with *Mimosa* was also without appreciable result on the white soils.

(5) Attention must be directed to the fact that the results described above have been obtained on the special soil types peculiar to a part of the East Coast of Sumatra, and it by no means necessarily follows that similar results will be obtained on other soil types. It is necessary to carry out field experiments on each characteristic soil type, before proceeding to practical manuring.

INTRODUCTION OF HEVEA.

In the course of an appreciation of the work of English scientists and explorers in connection with the development of the plantation industry, the editor of the *India-Rubber World* (70, No. 1, 429) says that while there is no question as to the fact that the British were the original successful producers of plantation *Hevea*, there may be some doubt as to which of the many distinguished botanists, collectors and agricultural experts first advocated *Hevea* planting. We, in this country, have, I think, long since come to the conclusion that the primary credit in this respect is due to Sir Clements Markham, and my friend, Mr. Pearson, after examining the evidence, arrives at the same conclusion. The following is the fine tribute paid by him to the man who well and truly laid the foundations of the plantation industry. "Explorer, scientist, essayist, and above all conscientious and wise administrator, Sir Clements Markham conceived and cultivated the native plants and trees in India as has never been done in any other country. He sent collectors all over the tropical world for seeds and plants. His collaborators and collectors, Cross, Collins and Wickham should have due credit, for the work they did was priceless. But it should be fully granted that it was Markham who first visioned the *Hevea* opportunity and then with quiet persistence worked until success was attained. His major triumphs were the introduction of *Cinchona*, and the bringing of the *Hevea brasiliensis* to the Far East."—Dr. Philip Schidrowitz in the India-Rubber Journal, Vol. LXVIII, No. 7.

[The facts relating to the introduction of *Hevea* into the East were summarised in the Annals of the Royal Botanic Gardens, Peradeniya, Vol. V, Pt. VII, in 1914. To make the foregoing note quite accurate, it should be stated that Cross was Markham's collector; Collins was not a collector, and up to the time he wrote his Report on Caoutchouc had not been out of England; Wickham was resident on the Amazon and was commissioned by Kew to collect seeds of *Hevea brasiliensis*.—Ed.]

PADDY.

VARIATIONS IN THE YIELDS OF SMALL PLOTS OF PADDY.

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(These trials were carried out by the students of the Farm School, Peradeniya, Ceylon, under the guidance of the Farm School Officer and his staff.)

It is practically impossible to find two areas of land which will give identical yields of crop, however similar they may be in appearance, and for that reason it is difficult to carry out satisfactory comparisons of yield of two or more types of a particular crop, or of the results of two or more systems of field treatment, unless the precaution has been taken to determine the initial differences existing between the plots which are being employed for the trials.

In Ceylon, the small quantities of manure which are customarily employed for paddy, and in general the small differences of yield which exist between many types of paddy, make it probable that in most comparative trials of manures or of varieties in the field we shall have to deal with only very small differences of yield which can rightly be attributed to variations in treatment or in type. It seems probable that, excepting in rare instances, the initial differences in quality of the plots are likely to be greater than those caused by the manures or arising from the change in variety of the paddy used.

The methods of measurement of land, of sowing the seed, of reaping the crops, of threshing the grain, and of measuring the paddy are extremely crude as practised by the villager, and from observed cases it seems certain that the error accompanying any one of these operations is often larger than any differences due to manure or to difference between varieties. In addition to these sources of error, it is probable that the methods of irrigation often are irregular and partial and in consequence introduce another complicating factor.

The trials described here were carried out primarily to ascertain the degree of variation existing between small plots of paddy on fields of apparent uniformity. At the same time it was hoped that reliable information would be obtained concerning other points of interest on which exact knowledge is lacking in Ceylon. The use of small plots enabled the measurements of areas and crop and the general supervision of operations to be carried out with a higher degree of accuracy than is possible on a larger scale.

OUTLINES OF THE TRIALS.

Details of the trials were given in the May, 1923, number of the *Tropical Agriculturist* and need not be repeated at length. The area selected was situated within one bund and could be irrigated as a single unit. The field seemed very uniform, and in yield was comparable to neighbouring village fields. The area chosen was rectangular, 80 feet by 70, and was divided into eight rows of seven plots each, each plot being 10 feet square. A selected strain of local Hatiel paddy was used, and the seed was sown in nurseries and the seedlings transplanted singly in the field

Count was made of the number of seedlings set out in each plot and of the number of mature plants at the time of reaping. In order to diminish losses, the grain and straw were separated by hand and weighed on laboratory balances. In general, therefore, operations were carried out with much greater exactness than is usual in large field-trials, the only one which could not be scrupulously carefully controlled being the measurement of irrigation water. The absence of cross-bunds and the small area of the block made it unlikely that irregularities in the distribution of water were very considerable.

RESULTS.

The trials were carried out during the two Maha seasons October to April, 1922-23 and 1923-24. In the first season the plants were set out at one foot square apart, this distance being reduced in the second season to six inches, so that in 1923-24 there were roughly four times as many plants set out to the plot.

Results for the two seasons are given below in order of merit of grain-yield. :—

1922—23.					1923—24.				
Plot. No.	Ozs. p. plot.	Grain. p. plant.	Ozs. Straw.	Mature. Plants.	Plot. No.	Ozs. p. plot	Grain. p. plant.	Ozs. Straw.	Mature. Plants.
A5.	118	1·25	224	94	F1.	102	·38	50	265
C7.	102	·95	160	107	E5.	100	·42	236	240
F3.	99	1·08	176	92	F3	96	·33	212	292
F2.	99	1·03	112	96	B1	93	·31	168	298
E3.	94	·80	160	117	C1	93	·34	193	275
D5.	89	·95	208	94	G1	89	·33	88	272
G2.	88	·97	176	91	E1	88	·30	188	292
A3	86	1·00	168	86	E6	87	·28	260	306
C6.	84	·78	160	107	C5	86	·29	228	296
F4.	82	1·17	144	70	C4	85	·26	225	325
G3.	81	·91	192	89	A3	82	·27	193	305
A2.	80	·78	176	102	E3	81	·20	168	312
A1.	80	1·25	160	64	F5	79	·24	232	324
B1	78	1·08	96	72	G3	78	·24	244	331
A4	77	1·00	144	77	A2	78	·29	168	270
H6	77	·81	112	94	D1	76	·29	208	258
A6	76	·80	128	95	D4	76	·25	176	305
F1.	75	·82	96	91	D7	76	·28	56	274
B2	73	·75	128	97	D5	75	·23	200	320
D6.	73	1·47	160	70	E4	75	·21	200	351
C5	72	·84	208	86	H1	75	·25	98	303
F5	70	·74	176	94	B4	74	·25	140	294
C1	70	·93	64	75	B5	73	·25	96	293
F7	69	·72	144	96	C6	72	·36	192	202
H5	69	·73	144	94	F4	71	·22	220	325
E1	69	·80	128	86	B2	70	·24	140	290
E4.	68	·73	144	93	F6	70	·25	200	274
C4	67	·82	112	82	E2	69	·44	164	158
D1	66	·79	192	83	A5	68	·24	166	285
G4	66	·79	176	83	G6	68	·24	184	278
B3	65	·72	144	90	C3	68	·24	152	284
B5	65	·75	128	87	A4	67	·22	114	308
G1	64	·81	96	79	G2	66	·26	200	248
D4	62	·75	176	83	A1	66	·20	148	331
D3	62	·54	144	114	C7	65	·23	144	283
D2	61	·77	160	79	B3	65	·28	92	232
F6	61	·71	96	86	D3	65	·23	140	277
G5	60	·67	128	90	D2	64	·23	136	282
A7	59	·59	112	99	F2	62	·23	112	270
C3	59	·64	128	92	H5	62	·21	184	291
G6	59	·70	80	84	G5	60	·18	44	340
H2	58	·73	128	79	D6	58	·19	176	312
D7	58	·72	128	80	B6	57	·24	72	240
E7	56	·60	128	93	A6	56	·24	148	220
G7	55	·59	112	93	G4	56	·17	212	330

1922—23.					1923—24.				
Plot. No.	Ozs. p. plot.	Grain. p. plant.	Ozs. Straw.	Mature. Plants.	Plot. No.	Ozs. p. plot.	Grain. p. plant.	Ozs. Straw.	Mature. Plants.
B6	55	·57	144	96	H6	55	·19	156	281
E6	53	·71	144	75	C2	54	·20	146	274
C2	53	·61	96	87	G7	49	·19	148	260
E2	52	·51	144	101	H4	49	·17	164	293
H3	48	·61	128	78	H3	46	·16	178	287
H7	48	·56	80	86	H2	44	·15	188	296
H4	46	·65	128	71	A7	43	·16	114	268
B4	44	·54	96	81	H7	42	·17	96	251
B7	43	·47	64	91	B7	40	·15	84	258
E5	40	·44	144	90	F7	35	·13	104	275
H1	31	·48	64	64	E7	30	·11	120	271
Means.	*68*	*·78*	*137*	*88*		*68*	*·24*	*158*	*287*
Standard deviations.	±16·55	±·21	±36·3	±10·64		±16·48	±·07	±51·37	±33·10
Probable errors.	±11·09	±·14	±24·3	± 7·13		±11·04	±·04	±34·42	±22·18
Coefficient of variability.	24·34	26·92	26·49	12·09		24·23	29·17	32·51	11·53

There are several points of interest in this table, among which may be mentioned the following :—

(a) The orders of merit of the 56 plots in yields of grain are not closely similar for the two seasons.

(b) The average yield of grain per plot chances to be practically identical for the two seasons. (68 ounces).

(c) The orders of merit for grain and for straw are not closely similar.

(d) Increase in the number of plants per plot has resulted in a decrease of grain per plant.

(e) The coefficients of variability for the two seasons are practically identical whether determined on grain or straw per plot or grain per plant.

These points are dealt with in greater detail in subsequent paragraphs.

COEFFICIENT OF VARIABILITY.

The yields of the plots vary very considerably, in spite of the facts that the field appeared unusually uniform and that all operations were carefully supervised. In the first season yields varied from 31 to 118 ounces of grain per plot, and in the second season from 30 to 102 ounces. In the previous article in the May, 1923, *Tropical Agriculturist*, it was shewn that some of this variation appeared to be attributable to progressive shallowing of the soil in two directions across the area.

The mean of the coefficients of variability calculated on grain per plot, grain per plant and straw per plot for the two seasons was 27·28. That the variation in yield is not entirely attributable to loss of plants is proved by the fact that the coefficient of variability for number of plants is only 11·81.

CORRELATION OF YIELDS OF THE TWO SEASONS.

The yields of the plots in ounces are correlated for the two years in

the following frequency-table. :—

Grain per plot 1923/24	Grain per plot 1922-23. 30	40	50	60	70	80	90	100	110	
30	·	·	1	1	·	·	·	·	·	2
40	·	4	3	·	·	·	·	·	·	7
50	·	·	2	1	3	·	·	·	·	6
60	·	·	3	5	1	2	1	1	·	13
70	1	1	1	5	2	5	·	·	1	16
80	·	·	1	3	1	1	1	·	·	7
90	·	·	·	·	2	·	1	·	·	3
100	·	1	·	·	1	·	·	·	·	2
	1	6	11	15	10	8	3	1	1	56

The correlation coefficient is ±·33 ±·08, which is low and indicates that the order of merit for these two seasons are not closely similar.

CORRELATION OF GRAIN AND STRAW.

In general, one would expect that the ratio between weight of grain and weight of straw would be fairly constant for the same type of paddy in the same season. One obvious error which must affect the ratio is the fact that the "straw" is only that part of the vegetative body of the plant which is above the ground : to get the true ratio it would be necessary to weigh the whole plant.

That there is a general relationship is shewn by the following figures for 1923-24:—

	GRAIN. Weight	% Total	STRAW. Weight	% Total
First 14 plots in order of merit. ...	1,239	32	2,685	30
Second 14 plots in order of merit. ...	1,030	27	2,258	29
Third 14 plots in order of merit. ...	904	23	1,992	22
Fourth 14 plots in order of merit. ...	656	18	1,920	19
		100		100

The percentage of the total weight of grain which occurred in each group of 14 plots is practically identical with the percentages of straws.

The actual degree of correlation between grain and straw is shewn by the following ratios:—

	Correlation coefficient.	
1922-23	±·42	±·07
1923-24	±·26	±·08

SPACING AND YIELD PER PLOT.

It is realised that the number of plants per plot which were present and mature at the time of harvesting cannot be accepted as exactly indicative of the space available per plant throughout the trial. Nor can the results be regarded as strictly similar to results obtained by careful experiments in regular spacing at different intervals. Nevertheless, if we find that there is a significant correlation between the number of plants and the weight of grain per plot, we must accept the increased weight as being due to closer spacing. The difficulty of conducting trials in which the number of plants per area is constant throughout the period of the trial is very great, and up to the present no satisfactory trial along these lines has been made in Ceylon. The results obtained are therefore given in some detail as being suggestive and of value.

In the correlation-tables given below the average space per plant in each plot in 1922-23 varied from 1·67 square feet to ·87 square feet, and in 1923-24 from ·67 square feet to ·29 square feet. The range of areas considered is thus considerable. Results are given in the following table.

Square feet per plant	Mature plants per plot	Grain per plot in ounces 1922-23									
		30	40	50	60	70	80	90	100	110	
1·67	60	1	·	·	·	·	1	·	·	·	2
1·53	65	·	·	·	·	·	·	·	·	·	0
1·43	70	·	1	·	·	2	1	·	·	·	4
1·33	75	·	1	2	2	2	·	·	·	·	7
1·25	80	·	1	2	4	·	·	·	·	·	7
1·18	85	·	1	1	3	1	2	·	·	·	8
1·11	90	·	2	3	4	3	2	1	·	1	16
1·05	95	·	·	2	1	2	·	1	·	·	6
1·00	100	·	·	1	·	·	1	·	·	·	2
·95	105	·	·	·	·	·	1	·	1	·	2
·91	110	·	·	·	1	·	·	·	·	·	1
·87	115	·	·	·	·	·	·	1	·	·	1
		1	6	11	15	10	8	3	1	1	56

The correlation coefficient is ±·37 ±·08. While this is not large, it points to a definite parallel increase in plot yield as the number of plants increases, within the range of spacing-distance covered by the table.

When we consider the figures obtained in the second season, in which the number of plants per plot is much greater, we find a much smaller degree of correlation :—

Correlation coefficient ±·10 ±·09.

This ratio is negligible, and therefore it seems clear that, somewhere within the range 1·67 square feet to ·29 square feet per plant, the point lies at which no increase of yield follows an increase in the number of plants per area. The ratios for 1922-23 and 1923-24 being each calculated for the

year's results as a whole, it is not possible to determine the point at which profitable increase of plants ceases.

SPACING AND YIELD PER PLANT.

The correlation between number of plants per plot and the grain per plant is as follows :—

Square feet per plant	Mature plants per plot	Grain per plant in ounces 1922-23. '40	'50	'60	'70	80	'90	1·00	1·10	1·20	1·30	1·40	
1·67	60	1	·	·	·	·	·	·	·	1	·	·	2
1·53	65	·	·	·	·	·	·	·	·	·	·	·	0
1·43	70	·	·	1	·	·	·	1	1	·	·	1	4
1·33	75	·	·	1	3	1	1	1	·	·	·	·	7
1·25	80	·	1	·	5	1	·	·	·	·	·	·	7
1·18	85	·	1	1	2	2	1	1	·	·	·	·	8
1·11	90	2	1	3	4	2	2	1	·	1	·	·	16
1·05	95	·	2	·	2	1	·	1	·	·	·	·	6
1·00	100	·	1	·	1	·	·	·	·	·	·	·	2
·95	105	·	·	·	1	·	1	·	·	·	·	·	2
·91	110	·	1	·	·	·	·	·	·	·	·	·	1
·87	115	·	·	·	·	1	·	·	·	·	·	·	1
		3	7	6	18	8	5	5	1	2	0	1	56

The correlation coefficient here is—·25 ±·08, showing that there is a slight decrease in the yield of grain per plant as the number of plants increases. In 1923-24 the number of plants per plot was greatly increased, and in consequence there is a much more marked decrease in the plant-yield as the number of plants increases; the correlation-ratio for 1923-24 is—·40± ·07.

This indicates that, somewhere in the range of spacing which was employed in the two seasons, a point lies after which any increase in the number of plants is followed by a marked increase in the yield of grain per plant. In this connection it is of interest to note that the mean plant-yield in 1923-24 is diminished exactly in inverse ratio to the increase in plants as compared with 1922-23 : thus :—

	Mean No. of plants.	Mean plant yield.
1922-23	88	·78
1923-24	287	·24

the calculated value for mean plant-yield 1923-24 being 88·X·78 ÷287=·239 as compared with the actual figure ·24 found.

SOILS AND MANURES.

THE ABSORPTION OF ATMOSPHERIC NITROGEN BY LEGUMINOUS PLANTS.

The use of leguminous plants for the improvement of soils is a practice of long standing, and it is now established that this improvement is effected by the absorption of nitrogen from the air by the agency of bacteria in the nodules on their roots. The general facts of the process are agreed upon, but there has been much discussion concerning its details, and several points are not completely decided. There have, however, been many experiments and investigations on the problem, and a considerable amount of information is available. As several correspondents have expressed a desire to know more about the subject than the mere fact that leguminous plants do take in nitrogen from the air, the following summary has been compiled.

The bacteria obtain entrance into the roots of the plant through a root-hair. Their presence within the plant causes a rapid cell division, so that a swelling or nodule is formed. This is analogous to the formation of galls as a result of an insect puncture or the attack of a fungus. The central portion of the nodule consists of parenchyma, while the outer layers are the same as the cortex of the root. The central tissue contains the bacteria. With the bacteria there occur other bodies which are known as bacteroids. The bacteria are rod-shaped, but the bacteroids are irregularly swollen and sometimes forked or Y-shaped. The latter are regarded as degenerated or involution forms of the bacteria; they are frequent in the nodules, but in artificial cultures they do not occur until the culture is old.

The nodules are most abundant and largest when the plants are growing in well-aerated soil. In saturated soils they occur at the surface. They will form on the roots of plants grown in water culture, but are not then as large or as active as in aerated soil. In dry soil they are much less numerous than in moist soil, but excessive quantities of water are injurious. One might summarise this by the statement,—the more root-hairs, the greater the chance of nodules.

It is believed that nitrates inhibit nodule formation. It is thought by some that the addition of soluble nitrates to the soil decreases the formation of nodules, and the same has been claimed for sulphates and ammonium salts. Legumes growing on a soil rich in nitrates may be immune to the nodule bacteria, and prevent their entrance into the roots, but small quantities of nitrates act as a stimulant.

When the plant produces seeds, the interior of the nodule decomposes, leaving the tougher outer cortex as a mere shell, which subsequently decays. This process, however, has only been determined in the case of plants which die after producing seeds, and it is not known to what extent it is applicable to tree forms, such as the Dadap and Albizzia.

As the formation of a nodule is the result of an infection by a particular bacterium, nodules can only be produced in soils in which these bacteria are present. Most soils do contain them, though in varying quantity. It sometimes happens that the first crop of a leguminous plant on a given soil may be poor owing to the comparative scarcity of the bacteria, while succeeding crops of the same plant improve owing to the increase in the number of bacteria through the growth of the host plant. The bacteria may be carried on the seed, or may be disseminated by wind or water.

The question now arises whether the nodules on all leguminous plants are caused by the same bacterium, or whether different species or groups of plants require different bacteria. This is a much-disputed question, and complete agreement has not yet been reached. It has been found that, in some districts, some leguminous plants could not be grown successfully when first introduced, until soil in which the plant had grown was imported for inoculation. That has happened in the case of lucerne and of soy bean. Again, where clover would not grow, success has been obtained by scattering clover chaff or straw over the land. Such examples point to the existence of different bacteria for different plants.

Numerous experiments have, however, shown that one species of bacterium can undoubtedly cause the production of nodules on many species of plants. Some claim that there is only one species which causes nodules on leguminous plants, but that it includes strains or races, each of which is accustomed to a particular group of plants. A recent classification divides these strains or species into eleven groups, those of each group being interchangeable with one another. Thus the bacteria found in the nodules of the various species of Clover (*Trifolium*) are interchangeable; those of Sweet Clover (*Melilotus*) will infect Lucerne and other species of *Medicago*; the Cow-pea bacteria will infect the ground-nut, Desmodiums and Acacias; those of the garden Pea (*Pisum*) infect the Sweet Pea (*Lathyrus*) and the Broad Bean (*Vicia*), but not the French Bean (*Phaseolus*); the Soy bean bacteria have for a long time been supposed incapable of producing nodules on other plants, but one experimenter claims to have successfully inoculated soy bean with bacteria from lucerne.

Leguminous plants are common in the Tropics, and it is most probable that all strains or species of their nodule-forming bacteria are represented there. Ceylon experience would favour that view, as no difficulty has been met with in establishing the numerous green manure plants which have been introduced.

It has long been known that, where the ground is poor in these bacteria, they can be introduced by scattering soil in which the desired plant has previously grown. The suggestion is immediately obvious, that more certain results would be secured by cultivating the bacteria by the usual methods in the laboratory and distributing the bacteria, preferably by inoculating the seeds, *i. e.* by immersing the seeds in water containing the bacteria. That was first tried in Germany by Nobbe and Hiltner, who distributed cultures on gelatine under the name of Nitragin, but on the whole these attempts were unsuccessful. Similar attempts were subsequently made by Moore in America, with a like result. More recently, Bottomley, in England, issued preparations of the bacteria, under the name Nitrobacterine,

and Stead's boom of this will no doubt be within the recollection of our readers. Marvellous results were claimed from the use of Nitrobacterine, but it was conclusively shown that the bacteria did not survive distribution. At the present day these methods of distribution are discredited.

Two methods of soil inoculation are, however, in use and are recognised as superior to the use of commercial cultures. Both these are based on the transfer of infected soil. One is simply the scattering of the infected soil over the new ground. The other is known as the glue method, and consists of first moistening the seeds with a ten per cent. solution of glue, and then sprinkling infected soil over them sufficient to absorb all the moisture.

The fact that the bacteria do absorb nitrogen from the air having been established, the problems arose, how they did it, and how the nitrogen was conveyed into the plant. And parallel with these are the questions,—Is all the nitrogen which is absorbed from the air taken up by the plant? Is any excreted by the nodules into the surrounding soil? If taken up by the plant, where is it stored? Are the leaves, etc. of a leguminous plant richer in nitrogen than a non-leguminous plant? It is evident that these questions touch on points which are of the greatest importance to the practical man, especially in the Tropics, where permanent tree forms are grown as green manures.

Several hypotheses have been propounded regarding the method by which the bacteria take up nitrogen from the air, but none of these has been established. As regards the absorption of the nitrogen by the plant, there are two hypotheses. One supposes that the bacteroids are absorbed by the plant fluids; the other, that the bacteroids, by some change, produce a nitrogenous substance which is absorbed by the plant. Neither of these has been proved. Consequently both the problems stated are still unsolved.

As regards the distribution of the nitrogen in the plant, several points are regarded as settled. Stocklasa, in 1895, found that, in the case of Lupins, the nodules were richest in nitrogen at the time of blooming (5·22 per cent.), and that their nitrogen content diminished as the fruits matured (to 1·73 per cent.). His results indicate that the nitrogen in the nodules is either taken up by the plant for seed production or is diffused into the soil.

Knisely analysed the different parts of lupin plants at three distinct periods of development. His results showed the following amounts of nitrogen, expressed as percentages of the dry weight :—

Period	Leaves	Pods	Stems	Roots	Nodules
Full bloom	4·02	3·07	1·15	·92	5·17
Pods well formed	3·70	3·38	·88	·83	4·29
Pods very large	3·41	3·68	·90	·66	3·70

It will be seen that as the pods mature, the percentage of nitrogen in the other parts of the plant decreases.

Exhaustive experiments on the fixation of nitrogen by Cow-peas and Soy beans have been made by Whiting. His results were published in Bull. 179, University of Illinois, Agricultural Experiment Station, from which most of the foregoing details have been taken. Whiting found that at the time of harvest about 74 per cent. of the nitrogen was in the tops, the remainder being distributed through the roots and nodules. In the earlier periods, the roots contain more than the nodules, but later this is reversed.

It has been shown by several investigators that if the plants are harvested at different stages there is an increase in the total nitrogen with each older stage, until the seeds are formed, when there is a substantial decrease. Whether this represents an actual loss has not yet been determined.

Hopkins analysed Cow-peas grown with and without bacteria. The following table gives one set of his results, the dry weight and amount of nitrogen being in centigrams.

	Parts	Dry Weight	Nitrogen percentage	Nitrogen amount
10 plants with bacteria	Tops	3,580	4·09	146
	Roots	620	1·45	9
	Nodules	190	5·97	11
	Total	4,390	—	166
10 plants without bacteria	Tops	1,560	2·42	38
	Roots	300	·88	3
	Total	1,860	—	41

"The infected plants contained nearly four times as much nitrogen as the uninfected plants, and about three-fourths of the total nitrogen in the infected plants was obtained from the air."

We can now answer some of our questions. According to the foregoing results, leguminous plants which are furnished with nodule bacteria contain a greater percentage of nitrogen than those which lack bacteria. This nitrogen is stored principally in the tops, *i.e.*, leaves and green stems. When the plant fruits, the percentage of nitrogen in all other parts decreases.

After the plant fruits the nodules decay, and some nitrogen will then be added to the soil, but it has not been determined whether any nitrogen is excreted into the soil at other times. The practice of growing together a leguminous and a non-leguminous plant dates at least from the days of ancient Rome, and it is claimed that the non-legume benefits by the presence of the legume by obtaining nitrogen from the latter. That this occurs during the second year of its growth might be expected, but a benefit in the first season is not sufficiently established.

The amount of nitrogen added to the soil by a leguminous crop has been estimated on several occasions in temperate countries. A gain of 200 pounds per acre has been reported by the New Jersey Experiment Station with crimson clover. In Canada, ten years' results with clover on a light sandy loam gave a yearly gain of 50 pounds of nitrogen per acre. In

the latter instance, the clover was cut and left to decay on the land. It was found that the crop contained from 100 to 150 pounds of nitrogen per acre, but that all except 50 pounds was dissipated by bacterial activities and in other natural ways.

It will have been noted that the facts which have been established concerning leguminous plants as green manures relate to herbaceous plants, and principally to annuals. Many of them will no doubt be applicable to the similar plants, *e. g. Crotalaria*, grown as green manures in the Tropics, but it is doubtful how far they can be applied to our permanent tree forms. Practically no investigation has been carried out on this subject under tropical conditions, and it is quite possible that such investigation might lead to a considerable modification of current practices.

It is especially of interest to note that, in the Canadian experiment referred to above, from one half to one-third of the nitrogen contained in the plant was lost in the process of decay. This illustrates one point which is in particular need of investigation in the Tropics. The amount of nitrogen added in the green manure has been estimated on many occasions, but how much of that goes to enrich the soil is another story. Under tropical conditions, the amount lost in decay is likely to be larger than in temperate climates, and it will no doubt vary with the practice followed, *i. e.*, whether the green material is dug in or whether it is left to decay on the surface. But all this awaits investigation.

Reference may be made to a few points, relating to green manures in Ceylon, which have been raised by correspondents. Some have pointed out rather indignantly that the nitrogen content of, say, dadap, stated in Bulletin X differs from that given in Bulletin Z. There are two explanations of that.

In the first place, in dealing with tree forms, the nitrogen content of the loppings will vary with the stage of growth of the loppings. Leaves contain a higher percentage of nitrogen than stems, and the soft green tissues contain a higher percentage than the wood. Consequently the younger the loppings the higher the percentage of nitrogen they will show on analysis. Old woody loppings will show a smaller percentage of nitrogen, because of the quantity of wood they contain. The only way to avoid this difficulty when comparing the nitrogen content of different plants is to have separate analyses of the leaves, green stems, and woody stems. It is to be noted that these statements refer to percentage of nitrogen, not to total quantity. The greater weight of the older loppings may involve a greater total weight of nitrogen, in spite of the smaller percentage.

A second source of discrepancies lies in the fact that, in order to give the planter some idea of the quantity of nitrogen which he is adding to the soil, the percentages of nitrogen have been based on varying standards, *i. e.*, the green weight of the plant, the sun-dried weight or the air-dried weight. All these are variables. About four-fifths of the green parts of a plant consist of water, and the green weight will vary with the weather and the time of day when cut. Similarly the sun-dried and air-dried weights will vary with the humidity and temperature of the air. To avoid these difficulties it is usual to express the weights of the various constituents of a plant as percentages of dry weight when dried at 100°C. Without that standard, the percentages are not strictly comparable.

Numerous analyses of green manure plants in Ceylon are scattered through various publications, but for the reasons given above these are not usually comparable with the analyses of plants in temperate countries. Nor can they be correlated with one another, in the absence of information concerning the relative amounts of leaf and stem, and the stage attained by the plant at the time the samples were taken.

One point revealed by these Ceylon analyses may, however, be referred to. *Indigofera anil* is said to contain 1·86 per cent. of nitrogen reckoned on the air-dried weight, and *Cajanus indicus* 1·88 per cent. on the same basis. These compare very unfavourably with the figures for Soy beans, but they are plants with somewhat woody stems and small leaves. The point, however, which is worthy of notice, is that *Passiflora foetida* contains 2·16 per cent. of nitrogen in the whole plant, and 3·81 per cent. in the leaves and fruits, reckoned on the same basis. Again, tea twigs, fresh, are said to contain 1·16 per cent. of nitrogen, while dadap loppings, fresh, contain 0·85 per cent., and *Crotalaria striata*, fresh, 0·86. These results again raise the question whether, in the tropics, the leguminous plants, in general, contain a greater percentage of nitrogen than non-legumes, and whether, apart from a possible excretion of nitrogen from the roots of the legume, manuring with any green stuff, as is practised in paddy cultivation, does not add as much nitrogen to the soil as manuring with a leguminous plant. If, however, the green stuff is grown *in situ*, it has to be borne in mind that the legume obtains up to three-quarters of its nitrogen from the air, while the non-legume obtains its nitrogen from the soil.

THE LEACHING OF FERTILISERS FROM SOILS.

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The subject of the leaching of fertilisers from cultivated and uncultivated soils stands out as one on which but little is known by practical agriculturists. This short article is therefore written with the purpose of supplying some information on the subject to those readers of this Journal, the great majority of whom are practical men, who perhaps have not had the opportunity of acquainting themselves with the results of scientific investigations on this important practical problem. Very little systematic work of this nature has been done in the Tropics, but at the Experimental Station at Rothamsted, Harpenden, England, experiments have been carried out continuously since 1870 to ascertain the loss of soluble fertilisers through drainage waters. The results of these bear out the fact that the losses from the soil of some of the most extensively used fertilisers is a factor that must undoubtedly be reckoned with. It is true the climatic conditions of the temperate regions differ from those of the Tropics, but if one considers rainfall only, the difference is merely one of degree, the rainfall of tropical regions being far more excessive. The liability of fertilisers to be lost from tropical soils through rainfall, drainage, and percolation is therefore greater than from soils of the temperate zone.

The experiments carried out at Rothamsted on the subject of the leaching of fertilisers from soils have been so systematic and the results obtained so conclusive, that one could do no better than embody in this article a summary of these experiments and of their results. Experiments were carried out to ascertain the leaching of fertilisers both from uncropped and unmanured soils, and from continuously cultivated soils. In the latter case, *e.g.*, the wheat plots on Broadbalk field, each plot was drained at a depth of from 2 feet to 2 feet 6 inches below the surface, and the drainage waters from these collected and analysed. For experiments with unmanured and uncropped land 'drain-gauges' or 'lysimeters' were constructed by building cement walls round blocks of earth *in situ*, and then gradually introducing a perforated iron plate below to carry the soil. These lysimeters were constructed to two depths, *viz*, 20 inches and 60 inches. The water draining from these lysimeters was collected every day and analysed.

Let us now consider what happens when each of the more important soluble fertilisers is applied to the soil, so far as their retention by or leaching from the soil is concerned. Of the nitrogenous fertilisers the nitrates of soda and of lime, the salts of ammonia and urea are freely soluble in water: Superphosphate alone of the compounds of phosphoric acid is soluble. The potassium fertilisers are all soluble.

Soil contains among other constituents clay and organic matter (humus). Now these two constituents of soil give to it certain properties which are peculiar to a class of substances called "colloids." Among other properties colloids have the characteristic power of "adsorbing" from certain solutions the substances dissolved in them. Besides this purely physical process, there may also be a chemical interaction between the salts in solution and certain chemical constituents of soils—the double silicates known as zeolites, and calcium humate. Experiments carried out by Way and Thompson, and later by Voelcker, have shown that all organic compounds of nitrogen, ammonium salts, phosphoric acid and potash were removed almost wholly from solution by ordinary soil, but that nitrates, sulphates and chlorides, chiefly of sodium and calcium, were not retained.

These experiments are confirmed by the analyses of water from the land drains. Ammonia, phosphoric acid and potash are found to occur only in very minute quantities, but nitrates, sulphates and chlorides of calcium and sodium occur in large amounts.

The Application of Sulphate of Ammonia to the Soil.—When sulphate of ammonia is added as a fertiliser to the soil, the soil water dissolves the particles of the fertiliser, and eventually the whole of the fertiliser goes into solution. There is no downward drainage or leaching of this solution, for part of it is adsorbed by the soil colloids, and part interacts chemically with the zeolites and humus and thereby becomes "fixed." Between the "zeolites" or double silicates of aluminium, calcium, etc., and the sulphate of ammonia in solution, there is an interchange; the ammonia replaces the calcium of the zeolite and this combines with the sulphuric acid of the fertiliser to form calcium sulphate which is washed out of the soil in the drainage water. Salts of calcium are therefore usually found in considerable quantities in the soil water. The action of these physical and chemical

factors results in the sulphate of ammonia being confined to the upper layers of soil. In the course of time sulphate of ammonia is converted by nitrifying bacteria to nitrate in which form only can it be taken up by most plants. As a result of this, any losses that the sulphate of ammonia will undergo, will be in the form of nitrate. Mention must be made here of the effect of the continuous application of sulphate of ammonia to a soil. This results in the depletion of its stores of calcium carbonate, which is brought about by the double decomposition it effects with the chalk or calcium carbonate in the soil, ammonium carbonate and calcium sulphate being formed. As the ammonium carbonate is nitrified, more calcium carbonate is utilised, and more calcium washed out into the drainage waters.

An examination of the results obtained at Rothamsted by the study of the composition of drainage waters from Broadbalk Field, shows that the amounts of ammonia found in the drains is very minute. When 400 lb. of ammonium salts per acre were applied to the plots, the amount of nitrogen as ammonia found in the drainage waters was not more than ·20 parts per million of solution. The effect however of adding ammonium salts or organic compounds of nitrogen to soils, is to increase the proportion of nitrate in the drainage water. Thus where minerals only are applied and no nitrogenous fertilisers, the amount of nitrogen as nitric acid found in the drainage water was 5·10 parts per million ; with 200 pounds ammonium salts, 8·50 parts per million and with 400 pounds 14·0 parts per million of nitrate were respectively found. The amount of lime found dissolved in the drainage water, as was to be expected, increased with an increase in the amount of ammonium salts. Thus, whereas the quantity of lime in the drainage water from unmanured plots was found to be 98·1 parts per million, with the addition of 200 pounds ammonium salts + minerals the quantity increased to 143·9 parts per million ; 400 pounds of ammonium salt increased it further still to 181·4 parts per million. Nitrate of soda has not the same effect on the leaching of the calcium salts from the soil as sulphate of ammonia, and the experiments at Rothamsted demonstrate that the addition of minerals + 550 pounds nitrate of soda per acre to the unmanured plot gave only 118·1 parts per million of calcium in the drainage water.

As regards urea, little need be said, for on application to the soil it is converted into the carbonate of ammonia in which form it is fixed by the soil ; the nitrogen it contains is thus not easily lost through leaching.

The Application of Nitrate of Soda to Soils.—Nitrate of soda is one of the most widely used nitrogenous fertilisers, and at the same time one that is most easily lost to the soil through drainage and percolation. Unlike sulphate of ammonia, there is no chemical interaction between it and other constituents of the soil, nor is there any "adsorption" of the fertiliser from solution by the soil. Moreover, nitrate of soda suffers from the disadvantage, from the point of view of leaching from the soil, that it is taken up by the plant almost immediately, whereas sulphate of ammonia has first to be converted into the nitrate before it can be utilised by the plant.

An application of nitrate of soda to the soil followed by rain, will result in great loss of the fertiliser through percolation into the drainage waters. That this is so is exemplified by the experiments at Rothamsted. Here where the rainfall does not amount to much more than 30 inches per annum, the amount of nitric nitrogen lost to the drainage waters on the addition of 550 pounds nitrate of soda per acre is no less than 18·4 parts

per million, as compared with 5·10 on the unmanured plot. The amount of nitrate found in drainage water will naturally depend on the season. Nitrates, in the temperate regions, should be applied as fertilisers in early spring, as then the crops need them for purposes of growth: but in the Tropics, the application must be considered chiefly from the point of view of rainfall.

What applies to nitrate of soda, holds equally good for nitrate of lime, and nitrate of ammonia. The former is deliquescent even when exposed to the atmosphere and hence is easily lost to the drainage water.

A word on Calcium Cyanamide will not be out of place. Calcium Cyanamide though not soluble in water, is transformed in the soil into urea and ammonium carbonate and hence is comparable in this respect to sulphate of ammonia.

In connection with the leaching of nitrates from uncropped soils, Russell and Richards summarise the results of experiments that have been carried out at Rothamsted without interruption since the year 1870. The drainage waters from the 20 inch and 60 inch gauge lysimeters, in both of which no crops were grown, were collected and analysed. As far as could be ascertained from the analyses, the nitrogen lost from the soil was found to be wholly in the form of nitrate. The amount of nitric nitrogen lost to the drainage water per acre per annum was 40 pounds. At the beginning of the experiment the percentage of Nitrogen in the top nine inches of soil was' 146, equivalent to 3,500 pounds per acre. At the end of fifty years, the percentage of Nitrogen was ·099, equivalent to 2,380 pounds per acre. The rate at which the nitrate was lost was comparatively slow. To account for this slow rate of loss of nitrogen from the soil, Russell has put forward the theory that soil organisms—algae, fungi and bacteria—accumulate the nitrate or the ammonia present in the soil, and on their death, decompose, giving rise ultimately to nitrate. These experiments also demonstrated that the amount of nitrate washed out from the soil was closely related to the rainfall.

The Application of Potassic Fertilisers to Soils.—Results of experiments at Rothamsted show that, like ammonia, potash is adsorbed by the soil, and the greater portion of it retained near the surface. Caustic potash is adsorbed directly, but in the case of the sulphate, nitrate and chloride of potash, the base is adsorbed, and the acids set free combine with the calcium or other bases of the soil, forming soluble neutral salts which are lost in the drainage waters. Thus calcium sulphate, nitrate and chloride are found in comparatively large quantities in the drainage water, whilst the amounts of potash are very small. At Rothamsted, analyses of drainage water from the wheat plot to which potassic minerals only were applied, showed that whilst the amounts of chlorine and sulphuric acid found were 11·1 and 66·3 parts per million respectively, the quantity of potash was only 5·4. Minerals + 200 pounds ammonium salts showed 20·7 parts of chlorine and 73·3 parts of sulphuric acid, but only 4·4 parts of potash in the drainage waters. Minerals + 400 pounds sulphate of ammonia gave only 2·9 parts per million of potash, but increased the chlorine and sulphuric acid to 26·1 and 90·1 parts per million respectively. The use of nitrate of soda was found to increase the amount of potash in the drainage water. Thus with Minerals + 550 pounds nitrate of soda, the amount of potash found in the drainage water was 4·1 parts per million. In the case of Kainit, the chloride it contains is usually lost in the drainage waters.

The Application of Phosphoric Acid to the Soil.—The usual phosphates applied as fertilisers to soils are superphosphate, basic slag and mineral phosphates. The two latter are, generally speaking, insoluble in water and hence are not lost to any appreciable extent in the drainage water. Superphosphate on the other hand is very soluble in water, and might therefore be regarded by practical agriculturists as a fertiliser that could easily be lost to the soil. This however is not the case, for superphosphate, on being added to the soil, reacts chemically with the calcium carbonate, hydrated ferric and aluminium oxides of the soil to form compounds insoluble in water. Thus, on the addition of superphosphate to soils, insoluble calcium, aluminium and ferric phosphates are immediately formed. Wherever calcium carbonate is present in soils, the soluble superphosphate interacts with it and precipitates the di-calcium or "reverted" phosphate. This is insoluble in water, but soluble in water containing carbon dioxide. On soils poor in calcium carbonate, and where iron and aluminium oxides are consequently abundant, phosphates of iron and aluminium are chiefly precipitated. These are insoluble in water containing carbonic acid, and are practically lost to the plant. To the latter class of soils lime must therefore be applied before the addition of the superphosphate. Besides the chemical changes it undergoes in the soil, phosphoric acid also undergoes the phenomenon of adsorption by the soil. Thus, there is no fear of excessive loss of phosphoric acid in the drainage water. In fact analyses of drainage waters show that the amounts of phosphoric acid present in them are hardly appreciable.

Another fact following on what has been stated in the foregoing, is that the phosphoric acid of soils is usually found to a very considerable extent in the top nine inches of soil. Dyer found that no less than 83 per cent. of the acid was found in the surface soil, and 27 per cent. in the subsoil, *i.e.* from 9 to 18 inches. An examination of the analyses of drainage waters at Rothamsted shows that the amount of phosphoric acid was never more than 1·66 parts per million. That was where superphosphate and 400 pounds of ammonium sulphate per acre were applied to the plot. The further addition of sulphate of soda or potash to this mixture resulted in a lowering of the amount of soluble phosphoric acid to 1·09 parts per million.

What has been stated in the foregoing refers chiefly to the results obtained at Rothamsted from an examination of the drainage waters of the wheat plots on Broadbalk field. They confirm in general the conclusions which were arrived at from a consideration of the question from chemical and physical grounds alone. The quantities of different fertilisers lost to the drainage water will, however, vary with the type of soil, the slope of the land, the crops cultivated, and the rainfall. Other experiments at Rothamsted have shown that more leaching takes place from light soils than from the heavier marls, loams and clays ; but irrespective of the type of soil, the same general results regarding the loss of fertilisers from soil were obtained. With regard to the crop grown, it is well known that different crops respond differently to different manures. The loss through leaching of a particular manure when applied to a particular

crop for which it is most suitable, will be less than when applied to another crop for which it is not so suitable. Thus nitrate of soda is more advantageously applied to the wheat crop than to barley, and there will be certainly less loss of the nitrate of soda through drainage from the wheat plot than from the barley. That the loss of fertilisers from the soil is dependent on the rainfall and slope of the land is evident to every one and needs no further reference.

SUMMARY.

As is well known, all nitrogenous compounds when applied to soil are converted into nitrates, and so are liable to be washed out into the drainage water. Nitrate of soda and nitrate of lime are, of all soluble nitrogenous fertilisers, the most easily lost from the soil, unless applied at a time when they could be very quickly assimilated by the growing plant, and when the rainfall is low. Excessive rain will leach out a large percentage of these fertilisers from the soil. The reason for this is that nitrate of soda is not "fixed" by the soil. Sulphate of ammonia on the other hand is "fixed" by it and hence not easily lost to the drainage waters. In fact, but little nitrogen is found in the drainage water in the form of ammonia, though a certain amount is lost as nitrate. Urea and calcium cyanamide are not lost from the soil as such, but as in the case of sulphate of ammonia a small proportion is lost as nitrate. With potash there will be but little loss, as it is largely adsorbed by the soil; but where kainit is used, the hydrochloric acid it contains will be washed into the drains. When sulphates are applied to the soil, *e.g.* sulphate of potassium, the potash is adsorbed by the soil, but the sulphuric acid is washed out. No fear of loss of phosphoric acid applied in the form of superphosphate need be entertained, as the latter is fixed in the soil almost as soon as it is applied to it. Of all the soluble chemical fertilisers, this is the one that is least affected so far as leaching from the soil is concerned.

MAURITIAN PEN MANURE.

PROFESSOR F. HARDY, M.A.

There is no need to extol the many virtues of pen manure, or reiterate the need of its greater employment in tropical agricultural practice. The main problem that confronts the planter in these days of mechanical tillage is how to manufacture larger quantities of pen manure with diminishing numbers of farm animals.

Bacterial Transformations in the Making of Pen Manure.—It is well known that pen manure consists of two main components, animal excretions and litter. Of the former, urine is by far the more important. It not only contains compounds of immediate fertilizing value, but also furnishes nitrogen to the organisms that bring about the decomposition of the cellulose of the litter into brown humus-like substances. Much of our knowledge of the cellulose-decomposing organisms is due to the researches of Dr. Hutchinson and his co-workers at Rothamsted. These investigators have demonstrated

that four main factors control the rapid multiplication of the more effective bacteria capable of decomposing cellulose. These factors are (1) an adequate supply of air, (2) an adequate supply of moisture, (3) a sufficiency of inorganic, or simple organic, nitrogen compounds, and (4) the absence of certain specific toxins, such as reducing sugars and *higher* organic nitrogen compounds. In the absence of an adequate nitrogen supply, however, it is interesting to note that deficiencies may be made up by the activity of certain nitrogen-fixing bacteria which can thrive on the first-formed decomposition products of cellulose, provided these products include readily oxidizable substances. Thus the nitrogen-fixing bacteria may work in conjunction with the cellulose-decomposing organisms, and thereby augment the initial supply of suitable nitrogenous material in the medium.

Artificial and Mauritian Pen Manure.—A natural outcome of the investigations of the Rothamsted workers was the formulation of a method for making artificial farmyard manure by treating straw with water, ammonium sulphate and finely ground limestone. This process has recently been patented, and its application will probably greatly aid in solving the problem of maintaining the humus supply of cultivated soils. In quite another connection, yet closely related to this subject, the Rothamsted researches have fully confirmed the soundness of a practice advocated many years ago by certain planters in Mauritius, whereby the output of pen manure on sugar-cane estates may largely be increased. Briefly, the practice consists in spreading machine-cut cane trash, herbage, or bush to a depth of 2 feet on the floor of a covered pen. Cattle are turned into the pen daily for a fortnight. At the end of this period, the urine-soaked litter is transferred to a pit whose floor and sides are composed of concrete or stone. In the pit, the moist material must not be stacked too loosely, else excessive decomposition, leading to "fire fang," may occur. Nor must it be packed too tightly, for exclusion of air may result in the formation of a sort of silage, owing to the development of an undesirable type of bacterial activity. The pen is afterwards again spread with cut litter, and the cycle repeated. When the contents of the pit have broken down properly, the manure is carted to the fields for spreading or suitably stored until needed. The changes that go on in pen and pit are probably somewhat as follows. The simpler nitrogenous compounds present in urine, chiefly urea, are either immediately utilized by cellulose-decomposing organisms naturally present in small numbers on the litter, or are quickly rendered available by conversion into ammonium compounds by fermentation. The organisms break down some of the cellulose of the litter, and thereby produce a suitable medium for the growth of nitrogen-fixing bacteria. These furnish simple nitrogenous compounds which quickly augment the nitrogen supply of the original medium, and allow of the further multiplication of the cellulose-destroying organisms. The process is therefore cumulative, and eventually the greater part of the litter is changed into humus. The end product is not only in a very suitable form for application to the land, but it also contains much greater amounts of nitrogen than can be accounted for by the relatively small quantity of urine originally present in it, because the nitrogen-fixing bacteria have also added their share of acquired nitrogen to it.

Advantages and Disadvantages of the Mauritius Method.—The chief obvious advantage of the Mauritius method for making pen manure is that much larger quantities of cellulosic material can be converted into manure by the penning of a limited number of animals, than is possible when the customary process of preparing pen manure is practised. Moreover, the Mauritius method may be adapted to the conversion into manure of widely diverse kinds of cellulosic material, such as straw, trash, grass, roughage, bush, and possibly even megass. Strictly aerobic and properly moist conditions must be maintained, however, for the method to prove successful. Its most serious disadvantages are the high initial cost of the trash cutter, pen and pit, and the expense of handling the manure during its preparation. On small estates, or under systems of very intensive cultivation, the Mauritius method may not, of course, be practicable, because it may not be worth while to use valuable land for producing the requisite material for litter.

A Mauritius Pen in Trinidad.—Through the courtesy of the Manager of the Ste. Madeleine Sugar Company, the writer is able to present the following data relating to a large-scale experiment carried out at Cedar Hill Estate, Trinidad. The plan of adopting the Mauritius system for increasing the supply of pen manure to the sugar-cane lands of the Company was suggested in 1923 by Mr. G. A. Jones, Agronomist in charge of Field Experiments. The pen is 100 feet long by 30 feet wide. It is divided into two equal compartments. Alongside the pen, and running its whole length, is a pit, 20 feet wide and 6 feet deep. A low wall surrounds both pen and pit The floor and wall are made of concrete, and the whole is sheltered by a galvanized iron roof. A trash cutter and blower-elevator, driven by an oil engine, are suitably housed in a small shed adjacent to the pit. In operation, one of the compartments of the pen is initially filled to a depth of 3 feet with finely chopped litter. It is generally not necessary to add water to the litter, but provision is made for a water supply to be used when megass is mixed with the litter, and during dry months when vegetation is parched. Cattle (20 head) are turned into this compartment daily for 14 days, litter being added each day. The second compartment of the pen is then put into commission, and the stock turned into it, whilst the contents of the first are transferred to the pit. By this plan, 2,000 tons of manure can be made per annum by 20 head of stock, or 100 tons per annum per head. By the ordinary method of preparing pen manure, only 20 tons can be made per annum per head, so that the Mauritius method is five times the more productive, under the conditions of this particular experiment. It is not necessary here to record the cost of cutting and carting trash and grass for litter, and of emptying the pen. The manager of Cedar Hill Estate Mr. E. E. Fabien, is convinced that, if a sufficient quantity of grass or other vegetation suitable for conversion into manure, can be grown on waste lands bordering railway lines, the Mauritius system will provide him with enough pen manure to apply to ratoons, as well as to plant canes. Formerly it was difficult to get sufficient material even for manuring plant canes alone. Furthermore, the new method will permit substantial reductions in the necessary quantity of stock, and it is expected that it will largely reduce the cost per ton of sugar-cane produced.

As regards the comparative fertilizer value of pen manure made by the Mauritius method, the results of analyses performed by the writer and recorded in the accompanying table, furnish sufficient evidence to prove

Sample	Moisture	Ash	Organic matter	Soluble humus†	Total Nitrogen	Nitrogen as Ammonia
	%	%	%	%	%	%
A	74·2	7·9*	17·9	12·0	0·184	0·005
B	78·0	3·8	18·2	12·3	0·216	0·002
C	77·0	4·3	18·7	14·0	0·220	0·0025
Average English farmyard manure	76·0	6·0	18·0	—	0·620	0·020

that it may differ but little from, and may be even superior to, pen manure prepared in the usual manner. The material analysed was obtained by the method of sub sampling from three 60 lb. samples of manure obtained from (A) an ordinary covered pen, in which fodder and bedding had been trampled by stock for three months, (B) one of the compartments of the Mauritius pen after three weeks trampling, and (C) the pit, where manure similar to (B) had been allowed to decompose for an additional ten days.

It should be noted that sample A differed from the others in being coarse and long in texture. One of the main factors for success in the Mauritius method is a comparatively fine texture in the pen litter. This enables it to take up and to distribute the urine of the animals that trample it, and thus to induce uniform decomposition throughout the mass. In conclusion it may be stated that one week's storing in the pit usually suffices for the production of a satisfactory manure. The material should then be spread at once, or piled in heaps until needed. To prevent "fire fang" and to minimise wasteful decomposition, the manure store-heap should be compacted during its formation by passing the carts across it. The heap may further be protected by covering it with a layer of soil, and by erecting over it a rough shed to shelter it from rain.

The writer's thanks are due to Mr. G. A. Jones of the Ste. Madeleine Sugar Company, and also to his colleagues, Messrs. S. F. Ashby and J. S. Dash for corrections and additions to the original draft of this article.—Tropical Agriculture, Vol. I, No, 8.

GREEN MANURES *VERSUS* ARTIFICIAL MANURES.

In the *Journal of Agricultural Science*, XI, pp. 323-336, Lipman and Blair recorded the results of experiments which had been carried on for 13 years, to compare the value of nitrogen in nitrate of soda, green manure crops, and farm manure, on various types of soil occurring in New Jersey, U.S.A.

* Determined by Piettre's method of extracting humus with boiling pyridine.
† Containing extraneous clay, 2·7%.

The experiments were conducted in cylinders, 23½ inches in diameter and 4 feet long, open at both ends. These were sunk into the soil until only 3 inches projected. They were filled with the local subsoil to about 10 inches of the top, and on this was placed 200 lb. of the particular soil to be tested. The surface area of the "plot" was 3 square feet.

Eight different types of soil were used, and four different crops were grown on each type each year. As the cylinders were run in duplicate this required 64 cylinders. But as five different manurial treatments were given to each combination ot crop and soil, the total number of cylinders was 320.

The manurial treatments were as follows:—

Series 1. No manure
Series 2. 640 lb. acid phosphate and 320 lb. potassium chloride per acre
Series 3. As in No. 2, together with 160 lb. nitrate of soda per acre
Series 4. As in No. 2, with leguminous green manure crops
Series 5. As in No. 2, with 15 tons stable manure

The manures in 2, 3, 4 were applied annually, the stable manure every other year.

The crops were rye, maize, potatos, and oats grown in a four-year rotation. The maize was planted thick, and harvested as forage. The rye was harvested at maturity. The oats were harvested at or near maturity. In the case of the potatos, the yield of both tubers and tops was included in the total yield.

The green manure was secured by sowing seeds of a legume immediately after harvesting the main crop. Vetches and clover were sown in the maize before the latter was harvested. These were allowed to grow until near the time for planting the next crop, when they were dug in. Soy beans made a fair growth before frost, while vetches and clovers were left through the winter. In some years, there was a partial failure of the green manure crops due to disease. It will be noted that this only allows a few weeks for the active growth of the green manures.

All the cylinders were limed once in five years.

Of the five different treatments, the green manure series gave the highest average returns on all the soils, though in a few cases scattered through the 13 years, and for the majority of the soil types during the first two years, the nitrate of soda series gave the largest yield. In a very few cases the yield of the stable manure series exceeded that of the green manure series.

The average yield of the nitrate series stands between the green manure and the stable manure series, the ratios being 100 : 83 : 72.

For a period of 13 years, leguminous green manures, grown in the period between the annual crops, have been more effective in crop production than 15 tons of stable manure every two years, or 160 lb. of nitrate of soda annually.

The nitrogen content of the soil has been maintained at a higher level with leguminous green manures than with nitrate of soda.

PESTS AND DISEASES.

BANANA DISEASES IN JAMAICA.

The following extracts are taken from the Annual Report of the Director of Agriculture, Jamaica, for the year ended 31st December, 1923 :—

Panama Disease was kept under very active control during the year and our staff of nine Inspectors was kept continually engaged throughout the year in carrying out quarantine measures under the "Order." It is satisfactory to note that the disease was thus so effectively controlled that the increase amounted to less than 6 per cent. over that for the previous year. With a disease of the nature of Panama Disease whose spread may readily gather momentum so as to cause a complete ruin of the industry in a short time when left to carry on its natural spread, such a result as has been recorded in Jamaica must be regarded as satisfactory and encouraging.

The original system of quarantine was devised by the writer when the disease was first discovered in Portland, in January, 1912. At that time the true cause of Panama Disease was unknown, there was no Mycologist on our staff, and preventive measures had to be drawn up in the absence of scientific knowledge of the causative organism of the disease. Although many experiments have since been tried the original procedure as laid down in the "Order" of 1912 still appears to be the most successful means of controlling Panama Disease and attempts to reduce the area of quarantine or to simplify the treatment have, so far, resulted in greater losses from disease in the end.

The secret of success in dealing with Panama Disease is prompt action on the first appearance of the disease. Any neglect inevitably results in a rapid spread of the trouble. The Department has had great difficulties to face in securing prompt measures on the lands of small cultivators who have been very apt to hide or ignore the disease, thereby causing a number of foci to be established in a district.

A trial is now being made of a new banana which was brought from Guatemala by Mr. R. White of South Manchester in 1914. This has been proved to be immune to Panama Disease by a crucial test on a diseased area on the Junction Road in St. Mary. The fruit is being accepted readily by the Fruit Companies and is very similar to the "Jamaica" Banana in appearance. It remains to be found, however, whether the American market will accept this "Robusta" banana when shipped in quantity.

Two nurseries each of an acre in area have been established at Buff Bay and Hope. Some seedling bananas grown from seed sent by Mr. Dewar from Nigeria are now growing at the Hope Experiment Station. Arrangements have also been made to raise seedling bananas by crossing some seed-bearing species on the Jamaica and Chinese Bananas. This work was started at Hope by Mr. W. Fawcett when Director of Public Gardens in 1902 but the seeds failed to grow. The results recently obtained at the

Imperial College of Agriculture at Trinidad show that it is possible to obtain seedling bananas by crossing seed-producing, inedible species with the "Gros Michel" of commerce. Now that the "Gros Michel" is failing as a commercial fruit due to Panama Disease, the question of raising an immune banana from seed has become a question of prime importance to all banana-producing countries. The position of Jamaica is peculiar in that the advent of an immune commercial banana that could be grown on immense areas in Central America at a very low cost would destroy its position as the leading banana country of the world. Planters in Jamaica are, therefore, viewing the outcome of this campaign in breeding new bananas with somewhat mixed feelings and are anxious that any new variety of value may be kept for the exclusive advantage of the Colony.

* * *

Panama Disease.—The figures of cases treated by the Inspectors of Plant Diseases or under their supervision, during the past year show that the number of actual cases treated represent a 40% increase on the previous year, while the number of diseased plants in these cases has increased by only 6%, showing that the inspection has been more thorough than in previous years. Most of the cases occurred in the parish of Portland, in districts where the disease has already been present for some years. During the year the disease appeared in two districts hitherto free from it—St. Catherine, and the Manchioneal district of East Portland. The large irrigated districts of the plains of St. Catherine still remain free from the disease.

Although this disease has been present in the island for a number of years, and in spite of the efforts of the staff of the Department of Agriculture, aided by that of the Jamaica Agricultural Society, to bring to the notice of the banana cultivators, and especially the small settlers, a number of elementary precautionary measures to be adopted with a view to the exclusion of the disease as far as possible from their cultivations, it is still evident that many small banana growers do not attempt to observe them. Large numbers of leaflets and posters were distributed throughout the banana growing areas of the island during the year, setting forth these measures. A more detailed account of the disease, together with the legislation and orders dealing with it, has been compiled and is now in the press. This will be distributed as soon as published.

A detailed account of the experimental work carried out at the laboratory and elsewhere was submitted during the year. Other experiments carried out since have confirmed the results obtained from the first series, which can be briefly summarised as follows :—

1. The *Fusarium* causing Panama Disease (*F. cubense*, E. F. Sm.) has been found to be indistinguishable in the laboratory from other Fusaria closely allied to it, which have been isolated from sources other than bananas suffering from Panama Disease. In spite of the most careful examination no cultural character was found to be sufficiently constant to serve as a means of distinguishing *F. Cubense* from its close allies of the group *Oxysporum* Wr.

2. Although such has been found to be the case in the laboratory, it has also been found that none of the numerous strains of *Fusarium* isolated from sources other than bananas suffering from Panama Disease, was capable of causing any symptom of this disease when inoculated into healthy banana plants. On the other hand, those strains isolated from vascular bundles of diseased bananas in the early stages of Panama Disease, have reproduced the disease when inoculated into healthy banana plants.

3. This indicated that there exists a difference between the two classes of cultures, one isolated from diseased bananas, and the other isolated from other sources, though no morphological difference can be noticed when they are grown side by side in culture.

4. The most successful method of inoculation has proved to be that used by Brandes (Phytopathology, 1919), by inoculation of the plant through the medium of the soil. This method has the disadvantage that it is very slow to show results, some months elapsing before any sign of the disease is visible externally.

A number of experiments were carried out in the field with a view to determining whether the present methods of treatment could be improved upon. Various methods were tried of destroying the diseased banana plant without disturbing the soil. The only successful results were obtained by using large quantities of Arsenite of Soda, applied to the "bulb" and the soil around it after the upper portions of the plants had been cut down and burnt. Under certain weather conditions this method gave good results, but when repeated some months later in very wet weather it would not work. It was considered that the present method used by the Inspectors of Plant Diseases, namely, digging out of the entire "bulb" and burning it, was the most reliable, even though attended by the disadvantage of necessitating considerable disturbance of the soil containing the fungus of the disease.

A large series of further experiments is now in progress at the laboratory, but results have not yet been obtained.

Black Spot Disease (*Cercospora musarum*, Ashby).—This disease, though quite common in Jamaica, is rarely of any serious importance to the banana grower. Under some conditions, however, it appears to become a more serious menace to successful cultivation. In consequence of correspondence from the Jamaica Agricultural Society on the subject of this disease, two visits were paid to the district of James Hill, Clarendon. Here the effects of the disease are much aggravated by adverse soil conditions, which weaken the plant considerably. A detailed examination and analysis of the soils of this district is being made at present, to determine whether by the application of suitable manures the effects of the disease upon the cultivations can be modified to any appreciable extent.

Heart Leaf Rot.—A number of specimens of this trouble were received during the year, and various organisms were isolated from the rotting portions. These included several strains of *Fusarium*, *Verticillium*, and four or five different Bacteria. Inoculations were carried out with the bacteria, by injecting them into the inner tissues of the "trunk" of healthy banana suckers. Up to the present no positive results have been obtained in this way, and the primary cause of the disease still remains undiscovered. The bacteria isolated from the rotting tissues appear to be purely saprophytic in habit.

Bonnygate Disease (*Sphaerostilbe musarum*, Ashby).—This disease is still present in several districts of the island, where it has been known to occur for a number of years. Owing to pressure of other work little

attention has been paid to this disease. Clean cultivation and the prompt treatment of affected plants are the best means of controlling this trouble.

Black Head Disease.—A few samples were sent in showing signs of this disease, caused by *Thielaviopsis paradoxa* (de Sey.) v. Hoeh., but this trouble is not serious from the point of view of the industry, and is usually limited to a single plant. It is comparatively of rare occurrence.

Marasmius Disease (*M. semiustus*).—This disease has been noted in several parts of the island, always appearing to be associated with other adverse conditions affecting the bananas. In some cases, bananas growing in dense grass have succumbed to the disease in a wholesale manner, probably due to the very moist conditions prevailing around the base of such plants growing under these conditions. In other cases the attack of the disease has been aided largely by moist climatic conditions, coupled with cold weather, as was seen during the early part of the year in the John Crow Mountains. Excessive nitrogenous manure applied around the base of the plants is also liable to result in an attack of *Marasmius Disease*.

BANANA WEEVIL BORER.

JOHN L. FROGGATT, B. Sc.,
Entomologist.

In consequence of numerous inquiries having been made on certain aspects of the Banana Weevil Borer problem, it is deemed advisable to make a brief summary of previously recorded observations, together with certain recommendations in order that a considerable amount of information may be gathered into a readily accessible form.

The egg is laid in a small burrow in the plant, generally about ground level, and lies just beneath the surface. The opening made for the deposition of the egg is practically closed by the shrinking of the tissue immediately surrounding the orifice, thus forming what is virtually a sealed chamber. The grub emerges in about eight days, and begins to burrow into the plant, closing the tunnel behind itself with waste fibre and excreta. For a portion of its life it works through the outer portion of the bulb, not only devouring tissue but also damaging many root origins, causing them to decay. It also tunnels through the heart of the corm, where through its voracious appetite it reduces the food storage capacity of the plant. When full fed it works towards the surface of the corm, and comes to rest in the end of the tunnel, with a very thin partition separating it from the soil. The grub takes, on the average, about 45 days to mature. In about two days it changes to the chrysalis. This stage in the life cycle is a resting one, during which a complete change in the structure takes place to form the beetle. This occupies a period of seven to eight days. The full-grown weevil on emerging is light in colour and very soft, and remains quiescent for several days, during which time it becomes darker and hard, black being the colour of the mature insect.

Once the beetle leaves the plant it lives in the soil or any old decaying banana material on the ground or in the stools.

The beetles live for a very long time when food is obtainable continuously. From laboratory observations the period extends over sixteen to twenty-one months, during the greater part of which oviposition, though more active in the spring and autumn, is continuous. Without food in dry soil they die in less than one week, but when the soil is damp they may live for several months.

The vitality of the adult weevils is well illustrated by the fact that they will survive as much as twelve days' complete immersion in water.

They will be generally found in old rotting stems and butts that are supersaturated with the fluids from the decomposition of the tissues. As many as thirty-nine live beetles have been taken from one old butt in a stool, and more than 100 from an old rotting stem on the ground.

The study of the effect of poisons on the adults has received a considerable amount of close attention. Although much work yet remains to be done on this line of investigation, it may be here stated that the two most satisfactory poisons used to date are Paris green and powdered arsenite of soda, both used dry and mixed with flour as a diluent, the former in the proportions of 1 to 6, and the latter 1 to 3. The mixture is sprinkled over the freshly-cut surface of a piece of banana corm, which is laid in or just outside any stool in which infestation has been found to occur. Very favourable reports have been received from banana-growers who have used this poison mixture, stating that they have found it kills numbers of the beetles.

This method renders the system of "baiting" a practicable proposition, for the labour and time spent in examining non-poisoned baits and destroying the beetles found was in many cases prohibitive.

This work has been dealt with in greater detail in the article on Banana Weevil Borer in the *Queensland Agricultural Journal*, May, 1924.

The very long life of the adults and the consequently lengthened period over which eggs may be laid render imperative the destruction of the beetles at as early an age as possible.

The dispersion of this pest may be brought about in one of three ways—

1. By transportation of suckers from an infested plantation. This is by far the greatest means of distribution. It is therefore to be most strongly recommended that care should be taken to plant suckers that come from a source free from the pest.

Where borer is present in a plantation suckers may be dug perfectly free from the pest; being left lying on the ground they act as baits for the beetles, and as a result some have eggs laid in them before they are carted away. Eggs may, of course, have been deposited in the plants while standing in the stool.

Should suckers be obtained from an infested source, the greatest care should be paid to the following precautions in order to minimise to the fullest extent possible the danger of removing infested plants :—

(*a*) No plant should be dug in any area that has been allowed to go out of cultivation, for the pest is always worse in such localities, as no measures have been taken to check it breeding.

(*b*) When dug the plant should have all trash, &c., removed, and the corm well pared, in order to cut away as far as practicable the portion in which eggs may be lying.

(*c*) As soon as this is done they should be put in a cart or slide (or, as a last resort in a bag) to prevent their lying on the ground and acting as baits. When a load is ready it should be taken right out of the plantation. Under no consideration should be suckers be allowed to lie in the plantation overnight, as the beetles are essentially night prowlers.

(*d*) Whenever possible it is most strongly recommended that each load of suckers be taken to the new site for planting, but where storage is necessary this should be done at a distance from the plantation, and they should be then kept off the ground.

2. There is no doubt but that the beetles may, and will, crawl from an old area into a newer one as the supply of plant material dwindles. Therefore, a new plantation should not be laid out close along-side an old abandoned one in which the pest is present.

3. By flying. There is no doubt now but that under certain as yet undefined conditions the adult weevils do fly. The information received to date on this matter is extremely scanty, the authenticated cases of normal flight all occurring between December and March. As this is an extremely difficult matter to experiment on, any information on observations made by growers will be welcomed—time of year, time of day, climatic conditions, wind, and the lie of the country are all important considerations in this connection.

As has been emphasised on previous occasions, areas which have been abandoned or allowed to go out of cultivation constitute a decided menace not only to the plantations in the neighbourhood, forming centres in which the pest may breed unchecked, and from which it may spread, but also to the district generally, as constituting a site from which suckers may be obtained for the taking.

Not only do crawling and flight always constitute means of dispersion, but also the wash after rain down gullies or steep slopes may carry beetles or portions of infested plant material for a considerable distance.

Once again attention is, therefore, drawn to this matter, which, if an effective control of the pest is to be aimed at, must be taken in hand. The plants in these old areas must be wiped out, and those in any area, as it goes out of cultivation, must be rendered unsuitable as a breeding-ground or site for shelter for the pest.

Control methods must, therefore, aim at preventing the pest breeding as far as possible. With this object, all old butts and corms should be so chopped up and stems split in half that they will dry as quickly as possible ; in that condition the fibre can be chipped in, and so retain the humus in the soil, or burnt. Such beetles as are present will then be forced to congregate in the vicinity of the stools.

To destroy the beetles in the soil, poison baits can be utilised, or untreated baits with subsequent hand collection and destruction of the weevils found. So far no effective treatment is known by which the plant can be protected from infestation, or by which the pest inside the plant can be destroyed.

It is hoped that facilities will be available in the near future to study both these aspects of the problems, so that data may be obtained from which conclusions may be drawn.

For the information of those to whom the Banana Weevil Borer is still stranger, a note on how to keep a watch for it may prove useful. Old corms, stems, &c., being a favoured breeding site, and easy to cut into, take a grubber or other tool and chop into them. If present, the grub tunnels will be seen, and on these being followed up a fleshy, white, legless grub, about half an inch long, with a red head, should be found. The holes in cross section will be circular in outline. The adult may also be met with, and is slightly less than half an inch in length, hard, black in colour, with a slightly curved trunk in front of the head.

The liberation of the Histerid beetle, *Plaesius javanus*, from Java, a known predator on the Banana Weevil Borer in its country of origin, is being continued in a small area adjacent to Brisbane. Although it is as yet too early to decide whether it has become established, several imagos of this beetle have been found alive two to three months after liberation.—Queensland Agricultural Journal, Vol. XXII, Part 3.

AGRICULTURAL EDUCATION.

THE STUDY AND TEACHING OF AGRICULTURAL ECONOMICS.

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In some countries it has long been recognised that in the general study of economic phenomena insufficient attention has been paid to the economics of agriculture, and that the results of the general studies of economic organisation cannot be applied to agricultural conditions. Amongst the countries which have recognised this fact may be mentioned the United States of America, Switzerland and Denmark, for in all these countries a highly developed organisation for research in agricultural economics now exists; and in the United States the teaching of agricultural economics has reached an advanced stage. In most of the universities facilities are provided for taking subjects in agricultural economics in degree courses leading to agricultural or to social science degrees, and in several of the most important of the universities post-graduate degrees are awarded for work in either agricultural economics or rural sociology, or in a combination of these subjects. Amongst these may be mentioned Cornell and Wisconsin Universities. Moreover, the study and teaching of agricultural economics and of rural social science has had a profound effect on the teaching of both agriculture and social science in the whole of the United States, and is now exercising a considerable influence on public policy in regard to problems of land, agriculture, and rural social organisation.

Institutions Teaching Agricultural Economics.—In England the first facilities for study of agricultural economics were provided in 1913 when the Institute for Research in Agricultural Economics was established at Oxford by the University and the Ministry of Agriculture supported by the Development Commissioners. During the war, special developments of study, particularly the study of the costs of production of farm produce, occurred, but these disappeared in 1920. During the last year provisions for the study of the *business management of farms* were made by the Ministry of Agriculture in connection with colleges and universities. Economics Advisory Officers, who will study the systems of farm management in their respective areas and take part in teaching principles of economic farm management in their institutions, were appointed at Oxford University; Cambridge University; Leeds University; University College, Reading; and Wye College, Kent. Minor provisions for the study of special problems of farm management have also been made at other institutions.

Before these later provisions for the study of agricultural economics were made several colleges or universities had made a practice of providing some teaching in economics for students in agricultural degree courses. This teaching was chiefly limited to economic history and general economic

theory, for organised knowledge was too scarce to admit of the teaching of agricultural economics *per se*. Amongst institutions providing teaching of this character may be mentioned the University College of Wales, Aberystwyth: Leeds University Agricultural Department; School of Rural Economy, Oxford; School of Agriculture, Cambridge; and Wye College, Kent. The School of Rural Economy, Oxford, included in subjects required for the Pass Degree those of Economic History of Agriculture, Economic Theory, Costs of Production and Marketing of Farm Products, Estate Management, Local Government and Administration. Amongst some of these subjects the students could choose, but they were required to take some economic subjects. Henceforth, it appears certain, students for degrees in agriculture in all universities will be required to take certain economic or social subjects of study, and the tendency will be to develop these departments of research and teaching.

Although progress is being made in teaching agricultural economics or rural social science subjects to students of agriculture, no advance in the opposite direction—of teaching agricultural economics or rural social science subjects to students of general economics or the social sciences—has anywhere been made. Yet there is sufficient divergence between economic and social phenomena in agriculture and rural life, and such phenomena in other industries and in urban environments, to justify their special study and also a special branch of teaching. Indeed, the time has now arrived when one or more universities could safely make provision for special study and teaching of agricultural or rural economics and of rural social science leading to an Honours or to a Post-Graduate Degree. Such a course should be open, and would have appeal, to students who have taken a Pass Degree in Agriculture, for which the course had included a preliminary study of economics, or to students having taken a general agricultural course and who wished to specialise; also to students who had taken a general course in economics and social science and wished to specialise in the rural aspects of these sciences.

Two Fields of Study.—The general scope of the study and teaching of agricultural economics covers two more or less distinct fields, *viz.*, (*a*) the factors in the internal management of the farm which determine the productivity of the enterprise and the remuneration of those who are engaged in it, whether workers, farmers or land-owners; and (*b*) the external factors which determine the course of production which is possible or desirable, and those which determine the prices of farm products. In other words, the two fields are those of the Economics of Farm Management and the Social Economics of Agriculture. Conditions of organisation, remuneration and life on English farms are determined not only by the conditions on the farms themselves, but also by forces which arise in other industries or within the agricultural industry of other countries. Therefore, it is not sufficient to study the economic phenomena of farming organisation apart from general economic and social phenomena connected with the industry over a wide geographical area.

Indeed, the scope and methods of study which past study and teaching of agricultural economics have shown to be necessary may be stated in

this way :—

(1) Economics of Farm Management	(*a*) Accounting method (*b*) Statistical method (*c*) Survey method (*d*) Experiment
(2) Social Economics of Agriculture	(*a*) Geographical method (*b*) Historical method (*c*) Statistical method (*d*) Survey method

Farm Management.— The study of farm management includes amongst other things the study of costs of production of crops and live-stock, and the factors which lead to high or low costs, whether technical or social. It also includes the results in profits and/or wages of organising types of cultivation or animal husbandry on a large or small scale ; the results in gross and net production of large and small-scale organisation ; and the social results, such as the effect on the family of different forms of organisation.

The most important results which the study of farm management, especially by accounting and statistical methods, has yielded, and is still yielding, are those showing the requirements in labour, food or materials for various processes. In such matters as the labour requirements per crop-acre, or dairy cow, in man-days and horse-days per acre or year, the study has yielded such results as will soon make it possible to state extreme variations and their causes, together with the average or standard requirements. The establishment of standards of this character will be of immense value to farmers, especially such as are developing experience, in that they provide criterias for the results of their own management.

Again, when results have been collected under sufficiently varying economic conditions and over sufficient geographical area, it will be possible to do some reliable cost estimating for guidance in making contracts which apply to goods to be produced in the future, as in the case of milk. Studies have shown remarkable constancy in certain proportions of costs due to various items, and when the price of items in cost, *e.g.*, labour or food, can be forecast, fairly reliable estimates of total costs can be made. It is, however, in the establishment of standards of requirements that accounting in particular holds out great hopes of practical assistance in internal farm management.

In its human aspects the study of farm management itself verges on the study of the social economics of agriculture and rural life. But the study of internal management also verges on the study of geographical or social phenomena in other countries, especially in relation to the systems and costs of marketing farm products, and the prices of such products in the home market. The social economics of the industry include all subjects which would be included in a general study of the social economics of all industries. But it may be said that the study of the social influences affecting the organisation of farming is of practical, and financial, as well as of cultural, value. In a study of British farming, knowledge of the recent history of

agricultural development in other countries, notably in the United States, the self-governing Dominions and in the countries of Northern Europe is of both cultural and practical value. Similarly, in the study of development of types and methods of English farming, knowledge of geographical influences in other countries as well as in this country is of cultural and practical value.

Methods of Study of the Economics of Farm Management.—As regards the economics of farm management *the accountancy method* has been used to discover principles and details of economical production of crops and stock. It can also be used to discover principles and details of division of income within the industry.

The Statistical method is used for the same purposes when less accurate detail is required, or when information is required over a greater area or a greater period of time than can be covered by accountancy.

The survey method is also used when complex influences have to be studied in relation to internal conditions on farms, and when large areas have to be covered. It is particularly useful when geographical or social influences have to be correlated with farming conditions.

By *experiment* is meant trial of methods under controlled conditions, and although this has scarcely yet been used in this country it has been used in other countries, and may be used here when sufficient knowledge has been obtained to make possible isolation of factors and definite trial of limited methods.

Methods of Study of the Social Economics of Agriculture.—As regards the social economics of agriculture, *the methods of geography* are important in the study of distribution of types of crop or animal husbandry in relation to soils, climate, contours, transport and markets.

The historical method applied to any period is useful for cultural purposes, but for practical purposes its application is chiefly to the last 170 years of agricultural development in Europe and the European settlements in other continents. In relation to the development of the science and practice of agriculture, it yields valuable results for the guidance of the farmer and the executive or administrative official.

The statistical method is applied in the study of the social economics of agriculture as in other social sciences, but there is still a vast field for the practical application of statistical methods to the study of economic phenomena in agriculture, especially in the relationship of the agricultural systems of exporting countries to those of countries like our own.

The survey method is being applied with a large measure of success to obtaining information partly geographical, partly technical and partly social in character. It is yielding information at once valuable to the farmer and to the constructive social engineer.

Economic Farm Management.—The branch of the general study which is most advanced in this county is that of economic farm management. Even in this sphere the study of systems and costs of marketing has made little advance. In this subject persons primarily interested in transport and commerce have large interest, and in many cases would welcome development of facilities for study and teaching. For the study of the social economics of the industry no university or institution has yet made adequate provision. The Ministry of Agriculture has stimulated, and will continue to stimulate, the study of internal economic management of farms, but it is necessary that an academic institution should stimulate the study of the wider aspects of the subjects. One aspect which would immediately repay study is that of marketing, or agricultural commerce.

Openings for Students.—As interest in the general subject of the economics of agriculture is rapidly developing, and the value of knowledge of economic phenomena is becoming recognised, it is practically certain that students of these subjects will find openings for careers. Indeed, in the United States of America, where the study and teaching of agricultural economics has had a great influence on farming policies and on agricultural social policies, the demand for men trained in this sphere has been equal, if not more than equal to the supply. In this country it is becoming recognised that men required for administrative posts connected with agriculture and rural life should receive an economic and social training definitely related to their sphere of activities rather than a purely technical training in agriculture.

Rural Sociology.—A subject closely related to agricultural economics is that of rural sociology, or the study of social phenomena in the rural environment. No attention has yet been paid to this study by any academic institution in this country, although, again, the study has advanced to a definite position in several American Universities. Such work as has been done in this country has been personally and privately undertaken. Many persons may doubt whether the development of special facilities for study or teaching in rural social science is either necessary or desirable, but there can be no doubt that in this predominantly industrial and urban country the study of social phenomena tends to be limited to the study of such in an urban environment. Nor could it be doubted that the study of rural social phenomena now needs a special stimulus.

A university which now has no very close agricultural connections but which has close connections with industry and commerce, could make for itself a special sphere in the development of the study and teaching of the social sciences related to agriculture and rural life. The welfare of persons in other industries and commerce is closely connected with conditions of agriculture, not only in this country, but in those countries with which they trade. Some studies of agricultural economics would be of practical value to them, in addition to adding to their knowledge and appreciation of general economic and social phenomena. The study of the economics of the industry, moreover, cannot be carried on without technical knowledge of processes in the production of crops and live-stock, but approach from the economic and social side enables the non-agriculturists more quickly to appreciate the importance of ruling conditions in the industry. In addition, the teaching of agriculture itself in this country is taking a decidedly economic trend. The present practice tends more and more to inductive studies of farm management, and of varying practices of crop and animal husbandry as a basis for agricultural teaching. Agricultural economics now provides a practical link between the study of social and other sciences. It also provides a link between the farming and the industrial or commercial communities. It is a subject which can be linked up with existing studies in universities in which social studies are carried on, but in which there is no special study of agriculture. The methods used in the study of agricultural economics are such as provide a wide training and discipline in general scientific methods, and the scope of the subject is sufficient to include matter of both practical and cultural values.—The Journal of the Ministry of Agriculture, Vol. XXXI, No. 3.

CO-OPERATION.

SUGGESTED EFFICIENCY-FACTORS FOR CO-OPERATIVE SOCIETIES.

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In attempting to compare the work of one Co-operative Society with that of another, the need is often felt for some factor which would serve as a basis of comparison. To be of value, such a factor would have to give concise expression to, or an actual numerical measure of, the amount of work performed by the societies and the degree of efficiency with which their affairs had been conducted. For the sake of convenience, it would have to be easy to calculate and simple to employ, and should be of such a kind that by its use an order of merit of efficiency could be drawn up for a group of societies.

The figure for paid-up capital naturally suggests itself as a possible basis of comparison, but, while this may measure the degree of activity shown in the matter of collecting share-capital, it affords little indication as to the efficiency with which money-lending, or other function of the societies, has been handled. The figures of membership, too, do not afford an entirely satisfactory basis, since it is possible for a society to be small and yet its work to be thoroughly efficient. In ordinary business enterprises, the annual profits, calculated as a percentage of the paid-up capital, are accepted as a satisfactory measure of the efficiency with which affairs have been conducted, but in the case of a small village co-operative society a high percentage of profit may be a sign of a poor spirit of co-operation.

These three figures would have to be taken into account when attempting to devise an efficiency-factor, but none is entirely satisfactory if used alone. In general, the work of co-operative societies in the Central Division is limited to the issuing of loans to their members, but in some cases their functions are extended so as to include trading-operations. From the point of view of any society, it seems clear that the collection of capital, the issue and recovery of loans in cash or in kind, the attraction to the society of deposits or Government loans, and the increase within safe limits of its membership, are all desirable and must be reckoned as "work;" these should therefore affect the factor which is being sought.

POSSIBLE EFFICIENCY-FACTORS.

During the past two or three years, the writers have tried the following factors:—

(a) $$\frac{(\text{Loans granted} + \text{Nett profit}) \times 100}{\text{Paid-up Capital} \times \text{Number of members}}$$

(b) $$\frac{\text{Total receipts} + \text{Total payments}}{\text{Paid-up capital} + \text{Deposits} + \text{Loans to Society}}$$

(c) $$\frac{(\text{Total receipts} + \text{Total payments}) \times 100}{(\text{Paid-up Capital} + \text{Deposits} + \text{Loans to Society}) \times \text{Number of members}}$$

The first of these factors gives the amount of work, taken as money-lending and measured in cents, done by every rupee of paid-up capital per member. It has the disadvantages of being applicable only to those societies which confine themselves to money-lending, and of not giving due consideration to the promptitude with which members pay back their loans. In this factor, all capital excepting paid-up shares is deliberately omitted: other capital is also used for making loans to members, but such other capital is attracted by reason of the efficiency of the society's work: it may therefore be claimed that such other capital should appear in the numerator but not in the denominator of the fraction, in other words should increase and not decrease the resultant factor.

In the second factor all receipts and payments are included, for example profits, additions to share-capital, deposits, loans to the society, loans issued to and recovered from members, purchase and sale of stores for trading, &c. All working capital is included, but the membership is not taken into consideration. The exclusion of the figures of membership appears to be a defect, since in principle every member of a society is expected to help, and therefore the existence of sleeping members should penalize the society by lowering its efficiency-factor. This factor gives the total work, measured in rupees, performed by each rupee of total working capital.

The third factor differs from the second only by taking the membership into account, and by increasing the magnitude of the factor by expressing it in cents instead of rupees. It seems to be, on the whole, a better expression of the efficiency of a society's work than are the other two.

EXAMPLES.

As an example of the kind of results obtained by use of these factors, the orders of merit of the societies of the Central Division are given below, using only the first and third factors :—

Financial Year May 1st, 1923 to April 30th, 1924.

Name and Age in years of Society.	Factor (a)	Name and Age in years of Society.	Factor (c)
1 K/Rickshawmen's (3)	13·01	1 K/Kandukara (1)	12·65
2 K/Kandukara (1)	4·63	2 K/Rickshawmen's (3)	9·84
3 K/S. Y. M. A. (5)	3·52	3 K/Dept. of Agriculture (3)	7·07
4 K/Eriyagama (1)	3·16	4 K/Eriyagama (1)	6·39
5 K/Kengalle (3)	2·18	5 K/Katugastota (2)	4·75
6 K/Atabage (2)	2·00	6 K/Atabage (2)	4·62
7 K/Medapalata (1)	1·98	7 K/Kengalle (3)	4 40
8 K/Mahanuwara (5)	1·87	8 K/Medapalata (1)	3·93
9 K/Royal Botanic Gardens (2)	1·74	9 K/Royal Botanic Gardens (2)	3·28
10 NE/Oyapalata (1)	1·64	10 K/S. Y. M. A. (5)	3·24
11 K/Dept. of Agriculture (3)	1·36	11 NE/Oyapalata (1)	2·96
12 M/Udugoda Pallesiya (3)	1·25	12 K/Mahanuwara (5)	2·48
13 K/Ganga Ihala (5)	1·19	13 KG/Gandolaha (4)	2·46
14 KG/Gandolaha (4)	1·09	14 K/Ganga Pahala (2)	2·34
15 K/Ganga Pahala (2)	·84	15 NE/Kotmale (1)	2·24
16 K/Harispattu (5)	·80	16 K/Uda Bulatgama (7)	1·70
17 NE/Udahewaheta (11)	·75	17 K/Kandyan Association (8)	1·43

Name and Age in years of Society.	Factor (a)
18 KG/Mawata pattu (6)	·61
19 K/Galagedara (11)	·38
20 K/Udunuwara (4)	·38
21 M/Matale East (5)	·29
22 KG/Three Korales (11)	·24
23 K/Katugastota (2)	·21
24 K/Kandyan Association (8)	·14
25 M/Nagolle (10)	·09
26 NE/Kotmale (1)	·05
27 K/Wattegama (2)	·05
28 M/Matale South (5)	—
29 K/Uda Dumbara (10)	·03
30 K/Uda Gampaha (10)	·00
31 K/Hataraliyadda (10)	·00
32 K/Uda Bulathgama (7)	·00
33 KG/Kitulgala (2)	·00
34 KG/Kanduata (6)	·00

Name and Age in years of Society.	Factor (c)
18 NE/Udahewaheta (11)	1·42
19 K/Ganga Ihala (5)	1·09
20 K/Harispattu (5)	·92
21 KG/Three Korales (11)	·91
22 M/Udugoda Pallesiya (3)	·89
23 M/Nagolle (10)	·88
24 M/Matale East (5)	·84
25 KG/Mawata pattu (6)	·81
26 K/Udunuwara (4)	·70
27 K/Wattegama (2)	·38
28 K/Galagedera (11)	·33
29 KG/Kitulgala (2)	·24
30 M/Matale South (5)	·22
31 K/Udagampaha (10)	·15
32 K/Hataraliyadda (10)	·13
33 KG/Kanduata (6)	·00
34 K/Uda Dumbara (10)	·00

In general, the two orders of merit agree closely. There are nine societies whose positions differ considerably in the two tables, namely K/S.Y.M.A., K/Department of Agriculture, M/Udugoda Pallesiya, KG/Mawata pattu, K/Galagedera, K/Katugastota, K/Kandyan Association, NE/Kotmale and K/Uda Bulatgama.

VALUE OF THESE FACTORS.

Two points may be noted, in connection with the table of orders of merit, which go to prove that the factors can be accepted as a real index to the efficiency with which the societies were worked. In the first place, those societies which have had to be, or will have to be, closed down all occur in the lower half of the table; for example KG/Beligal Korale and NE/Walapane had factors ·00 and ·01 and have been closed down: KG/Galboda with a factor ·00 was temporarily suspended until its affairs improved, and M/Nagolle, K/Uda Dumbara and K/Kandyan Association (·88, ·00, and 1·43) are being closed down.

The second point is that all the older societies occur in the lower half of the tables. No society older than 5 years is found among the first fifteen, while among the last nineteen in the table there are three of eleven years, four of ten years, one of eight years and one of seven years old. The explanation of this appears to be that, in the early years of the movement, societies were founded with too large areas of operation and also that they were under far less supervision and guidance than they are now. Among the last nineteen there are eight each of which extends over a whole Ratemahatmaya's Division, while among the first fifteen there is only one; in general the newer societies are limited to small areas or are confined to special groups of individuals, and the rise in efficiency is very marked.

SUMMARY.

These factors have been put forward frankly as suggestions and without intention of claiming any extreme merit or virtue in their use. At present it is difficult to compare the efficiency of various societies, and the need for some means of comparison arises frequently. In the case of the societies of the Central Division the order of merit given by either of the two factors reflects correctly the general impression, gained during 3 years of audit, of the relative soundness of the various societies.

GENERAL.

THE IMPROVEMENT OF THE COCONUT *JAGGERY* INDUSTRY ON THE WEST COAST.*

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In a previous communication on this subject, published in the *Agricultural Journal of India* (Vol. XVII, Part IV.), it was pointed out that the coconut *Jaggery* (unrefined, raw sugar) industry on the West Coast afforded ample scope for improvement, and that, by the adoption of a simple sand filter and the use of alum for deliming the juice, it has been possible to obtain a better type of *jaggery* in point of cleanliness, colour and keeping quality than is to be found anywhere on the West Coast.

Analyses of a large number of samples show that *jaggery* prepared by us at the Kasaragod farm was by far superior to anything of the kind sold in the market. The table below gives typical analyses of the two kinds of *jaggeries* :—

Comparative analyses of Coconut *Jaggeries*.

Country *Jaggery*			Kasaragod *Jaggery*	
	Sucrose %	Glucose %	Sucrose %	Glucose %
(Elimalai)	78·22	5·38	77·1	3·6
(Ponnani)	68·81	0·07	73·5	2·0
	75·36	4·00	83·5	3·2
	62 80	0·06	77·7	3·2
	61·18	11·37	77·8	3·8
(Podanur)	73·45	1·11	87·5	2·6
(Perur)	73·23	1·96	85·4	2·2
	73 58	2·18	83·3	5·2
(Kalmandapan)	71·57	2·24	86·5	4·2
(Perundurai)	71·29	0·83	85·4	4·2
	72·32	2·33	86·5	3 8
	69 58	4·15	85·4	6·6
			81·6	2·6
			80·3	3·6
			82·2	1·8
			81·0	2·2
			79·0	4·4
			80·6	3·6
			79·0	4·8
			81·9	3·0
			78·0	3·6
			81·0	3·4
			78·7	4·4
			80·3	3·2
			77·4	5·8

* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924

The improved kind of *jaggery* is well appreciated and commands a good demand. At the time our experiments were running, while the price of outside *jaggery* was 1½ annas a pound and easily available, the *jaggery* made on the Kasaragod farm was in great demand even at the enhanced rate of 2 annas a pound.

How the improved product is appreciated by the public may be seen from the following extract from an article in the *Madras Bulletin of Co-operation* (Vol. XIII, No. 8, p. 294) entitled "The Co-operative Manufacture of Palm *jaggery*" by Mr. M. Shiva Rao of Puttur, South Kanara :—

"It may no doubt look as if an increased output of *jaggery* may not help to keep down prices at a reasonable level, since certain orthodox classes will never take to it however cheap it might be, and they would always be using cane *jaggery*. There is some force in this view but a change in the present method of manufacture of *jaggery* will, in all probability, take the citadel of orthodoxy by storm, and the sentiment against palm *jaggery* will be considerably weakened and disappear altogether in course of time. The fact has first to be published that what is called 'Palghat' *jaggery* and also the 'Ghati' *jaggery* coming from up-country and imported into this district is no more than palm *jaggery* prepared out of the sweet toddy of the 'Ichalu' (date palm). Secondly, palm *jaggery* should not be manufactured into flat thin round cakes as it is done now but made into cubicles of the same shape and size as the Palghat and Ghati variety. If it is thus put into the market, I believe, it will mend or end the existing sentiment against it. I do not put this forth as a mere theory but as a certain consequence, since it has been experimentally tried and found to succeed. Through the kindness of the Kasaragod Co-operative Inspector in South Kanara I had recently got samples of *jaggery* prepared out of coconut sweet toddy in the Government Coconut Station at Kasaragod, and some of my orthodox Brahmin friends gladly took samples from me after tasting them in my presence. They were immensely pleased that such fine *jaggery* could be made in our district and they seemed almost anxious to start the industry themselves on a sufficiently big scale".

This paper deals with some of the difficulties which are likely to occur in the collecting of *juice* and making of *jaggery* and experiments on the production of brown sugar from coconut sweet juice. It will be some time before a full detailed report on the subject of coconut sugar production, from the tapping of the juice to the marketing of the finished product, will be available. It is, therefore, considered desirable that the results of further experiments on *jaggery* and brown sugar production should be published as a second notice.

The making of *jaggery* by the improved alum method on the Kasaragod farm was continued for the major portion of the year 1922, and invariably hard light-coloured *jaggery* was obtained. Suddenly, about the end of March of the same year, it was found that when the juice was concentrated as usual it would not set to *jaggery* either by the improved alum method or the usual village method. All sorts of modifications in the technique of boiling were tried to no avail. The juice as brought down from the tree was tested for any fermentation, but no signs of it could be discovered,

Eventually the trouble was traced to the improper cleaning of the pots. Experiments 1-3 detailed in the Appendix clearly show that the trouble arose on account of imperfect cleaning of the pots in which juice was collected. It appears to us that as a consequence of inefficient cleaning of the pots incipient fermentation set in, with the result that the usual setting of *jaggery* was seriously interfered with.

Our experiments distinctly show that proper washing and liming of the pots and putting them mouth downwards when not in use is ordinarily enough; but where for any cause this is found insufficient, rinsing the pots with water in which a small quantity of copper sulphate is dissolved, and subsequent washing and application of good lime will improve matters. This method of cleaning can be easily adopted by the tapper as the amount of copper sulphate required is so small that it would not cost him more than a quarter to half an anna, and this quantity can be used for a number of pots successively. If after use this is stored in a small pot the same copper sulphate can be used a number of times.

BROWN SUGAR.

The idea of preparing brown sugar direct from the coconut juice appeared feasible in view of the fact that *jaggery* prepared from unfermented juice was markedly crystalline in structure, and showed very little glucose on analysis. A small centrifugal butter drier was kindly placed at our disposal by the Superintendent, Central Farm. Fitted with a cylinder of brass wire netting with very small meshes, this proved quite suitable for our experiments. To prepare the sugar, boiling was stopped a little short of the *jaggery* moulding stage, and the syrup left to cool and crystalize in a shallow vessel. The time taken for complete crystallization and the size of the crystals depended of course on the concentration at which the syrup was removed off the furnace. With a little experience one could easily judge the stage at which the maximum amount of crystallization would take place. Percentage of sugar obtained this way ranged from 7·5 to 9 on the weight of juice or 55 to 65 on the weight of *jaggery*. Details of a few typical experiments are given in the Appendix. Nothing like thoroughness is claimed for these trials which were only slightly larger than laboratory scale experiments. Our object in describing them is merely to show that a good crystalline sugar of fair purity could be easily obtained from the juice of the coconut. One reason why it is worth while to prepare brown sugar, at least in the rainy season, in the place of *jaggery* is that the sugar has much better keeping qualities than the *jaggery*. It sold at 3 annas a pound when *jaggery* was selling at half the rate, so that taking the yield at 50 per cent. on the *jaggery*, there would be no loss at all. If the molasses could be utilized, it would even be a distinct source of profit.

ECONOMICS OF THE INDUSTRY.

In view of the proposed publication of a detailed report on the subject in all its aspects, we do not propose to deal at length with the economics of the industry. But, as our object is to stimulate *jaggery* production, we wish to emphasize the fact that *jaggery*-making is more profitable than either selling the juice as toddy or leaving the tree to bear nuts. As the coconut

juice is drawn from the inflorescence, the use of a tree for *jaggery* manufacture would mean the entire stoppage of the supply of nuts and the consequent loss of revenue under that head. The juice itself may either be boiled into *jaggery* or collected without any preservative and sold as fermented toddy. For the latter the tapper has to obtain a license on payment of Rs. 7-8 a tree per year. When working out the economics of the *jaggery* industry, therefore, a comparison has to be made between these three sources of income from the tree. The average daily yield of juice from a fairly good tree may be taken at two bottles or roughly 3½ lb. This quantity would boil down to ½ pound of *jaggery* fetching 9 pice a day or Rs. 17 a year. Of this, a sum of about Rs. 2 has to be paid to the owner of the tree. Deducting Rs. 4-8 for fuel purchased—granting that fuel has to be purchased throughout the year, and that the expenditure under this head would amount to about a fourth of the sale proceeds of *jaggery*—the net profit would be Rs. 10 a year from a tree. If, on the other hand, fermented juice is drawn and sold to the shop renter at the usual rate of 4 pice a bottle, the income under this head would amount to Rs. 15 a year. After payment of Rs. 7-8 as tax and Rs. 2-8 to the owner, the tapper gets only a profit of Rs. 5. Now such a tree may be supposed to yield about a hundred nuts a year. At the normal rate of Rs. 50 a thousand, the amount realized by the sale of nuts would come to Rs. 5 only. The amount due to the owner may be considered balanced by the saving on tapping accessories, etc. Of the three, therefore, the tapper finds *jaggery*-making the most profitable, besides being a source of daily income to him.

In conclusion, our thanks are due to the Deputy Director of Agriculture, VII Circle, and the farm staff at Kasaragod for facilities afforded for our work.

APPENDIX.

Experiment 1.—14 pots were well washed, smoked, rinsed with dilute copper sulphate solution, and washed again with boiling water. 20 c.c. of formalin were put in each of four of these and the remaining ten were limed. All were then kept on spathes that yielded well. The contents of the formalined and limed pots were collected separately the next morning and analysed with the following results :—

Formalin		Lime	
Brix	Sucrose %	Brix	Sucrose %
16·64	14·40	16·33	13·34

Liming was normal, juice clear and distinctly alkaline.

The juice collected with formalin was made just alkaline with KOH, and the limed juice simply filtered clear. The two were boiled down separately. *Jaggery* from formalined juice was very hard and light-coloured and kept colour; that from the limed juice set well and kept colour, though it was not as hard as the other. *Jaggery* from the usual boiling set also, but was not as hard as either of these.

Experiment 2.—Pots were subjected to the same treatment as above. Trees selected for formalined and limed juices were the same as before. Analysis of juice showed :—

Formalin		Lime	
Brix	Sucrose %	Brix	Sucrose %
16·48	14·65	16·14	13·12

Liming slightly above normal. Formalined juice was strained through cloth only, while the limed one was filtered through sand. The former gave the same hard, good-coloured *jaggery* as on the previous day, but the *jaggery* from the limed juice was soft and darkened soon. The product of the usual boiling did not set.

Experiment 3.—Pots treated as above, but all were limed only. Juice from the four spathes from which formalined juice was drawn on the previous days was collected separately. Analysis :—

Limed (Four pots used for Formalin previously)		Limed (The ten remaining pots)	
Brix	Sucrose %	Brix	Sucrose %
16·44	13·85	16·68	13·98

Liming slightly above normal. Juice from all the pots was mixed and strained through sand. Half was boiled down straight away and the other half treated with alum, allowed to settle, decanted and boiled. The untreated juice gave the usual soft *jaggery*, whereas the one treated with alum gave a very hard, light-coloured product.

BROWN SUGAR.

Experiment 4.—Amount of juice available for boiling was 134 lb. When concentrated sufficiently (temperature 116°C.), it was allowed to crystallize in shallow pans and centrifuged after eight days. Crystals were large and well defined.

Yield : 10 lb. brown sugar and 14 lb. molasses.

Yield of brown sugar=7·5 per cent. on juice or 53·2 per cent. on *jaggery*.

Experiment 5. Weight of juice 120 lb. Juice arrived at the shed by about 11·30 a.m. Preliminary sand filtration was over by about 12 noon. Alum was added and the juice boiled, and allowed to settle for 2 hours. Sample taken just before leaving to settle showed : Brix 17·34, sucrose 13·24, glucose 0·91.

After 2 hours the juice was decanted. It was clean and bright. Just before beginning to boil at 4 p.m. another bulk sample was drawn and

analysed to see if any inversion or fermentation occurred. Analysis : Brix 17·47, sucrose 13·40, glucose 0·91. The syrup was taken out to crystallize at a slightly later stage than before and while hot a spoonful of white sugar was stirred in. Crystallization was complete by next morning. Centrifuged at once. Crystals were finer and better coloured than on the previous day.

Yield : 11 lb. sugar and 9½ lb. molasses. Percentage of sugar on juice=9·17; on *jaggery*=65·5 (assuming the yield of *jaggery* to be 14 per cent. on weight of juice).

Crystals being very fine, the molasses contained a good deal of sugar that passed through. It was, therefore, slightly further concentrated and left over. No crystallization occurred on the next day. A few crystals of white sugar were stirred in. No further crystallization was observed even after four or five days.

Experiment 6. Weight of juice collected was 149 lb. Juice arrived at 12 noon and was filtered and alummed by 1 p.m. and allowed to settle till 3 p.m. It was then boiled down till temperature showed 116°C. Juice analysed before settling showed : Brix 16·51, sucrose 13·34, glucose 0·77. Clear juice drawn off at 3 p.m. before concentration gave : Brix 17·69, sucrose 13·35, glucose 0·83.

By next morning a plentiful crop of crystals appeared. Syrup was centrifuged after 3 days.

Yield : 11½ lb. sugar and 12 lb. molasses

Percentage of sugar : 7·7 on juice or 54·8 on *jaggery*.

Analysis of a sample of molasses showed 50 per cent. of sucrose. With more efficient arrangements for the separation of crystals, the amount of sucrose could probably have been kept down further still.—Agricultural Journal of India, Vol. XIX, Part V.

SUGAR-PRODUCING PALMS.

NIPA FRUTICANS, OR NIPA PALM.

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The following extract is taken from an article on Sugar-producing palms in *Facts about Sugar*, July 21—September 15, 1923.

"Nuts of a similar plant", says Seemann, "abound in the tertiary formations at the mouth of the Thames, where they once floated about in as great profusion as those of the *Nipa fruticans* do at the present time in the rivers of the Indian Ocean, until they became buried in the silt and mud which now form the Island of Sheppey."

DESCRIPTION.

Seemann says of the Nipa that it partakes so much of the habit of the palm that it is generally considered as such and may be near enough for popular purposes, and further that scientists have found it a close

ally of the palm. It is a stemless plant, with a stout, branching root-stalk about 1½ feet in diameter, from which the leaves and inflorescence rise. The leaves are pinnate and from about 9 to 30 feet long. At the end of the second year the plant has about 7 or 8 leaves and this number it maintains through life. The fruit is a one-sided drupe, nodding, globose, and about as large as a man's head. It requires about four months to ripen. The plant flowers at the age of four years. The flowers are monoecious, axillary, and enclosed in a spathe. The plant is reproduced both by seed and the branching rhizome. It is said that to keep a Nipa swamp in good condition it must be thinned until the trees are from 1·5 to 1·7 meters apart. The Nipa is one of the most beautiful plants in the Philippine Islands.

HABITAT.

The Nipa grows in tidal areas throughout all the Eastern Tropics. It seems to thrive only in brackish swamps, or low, wet land, subject to overflow of brackish water, and will not thrive in localities where either fresh or sea water alone is available. Thousands of acres of the salt marshes of the Islands and coasts of the Indian Ocean are covered with Nipa. Hemsley reported it as exceedingly common on the seashore of Tropical Asia from the North of the Ganges and the Philippines to New Guinea and North-Eastern Australia, and also reported it on the Solomon Islands. As stated in the *Gardeners' Chronicle*, Sir Joseph Hooker observed large nuts of this palm floating about in the delta of the Ganges in such numbers as to obstruct the paddle wheels of steamboats. The tree is found in the river estuaries and tidal forests of the Sunderbans, Chittagong, Burma, and the Andaman Islands, and is distributed from the Malay Peninsula and Ceylon through the Malay Archipelago to Australia. It is one of the few tropical plants that occur in pure stands over extensive areas in Borneo. The British North Borneo government estimated that in 1920 at least 300,000 acres existed at very accessible points throughout its territory.

The plant grows wild in the Philippines and in great profusion on land largely useless for other purposes. It appears as the commonest and characteristic growth near the upper limits of high tide and on strips along the tidal portions of fresh-water streams, and is often found in nearly pure stands. Nipa swamps of considerable size and importance occur in a number of provinces, the Nipa district bordering on Manila bay ranking first in these respects. According to J. F. Boomer, "There are over 100,000 acres of Nipa swamp now available in the Archipelago," of which "about ninety per cent. has never been touched," and a large portion of this area "is still at the disposal of the government and at the same time can be leased for 10 per cent of the raw material produced each season."

Merrill believes that "the species will grow in Southern Florida, and will certainly grow in most parts of the West Indies and Central America if planted in its proper habitat." Piper believes it probably adapted to the coastal conditions in extreme South Florida, and Merritt and Whitford claim that "Evidently the Nipa would grow and do well on the land occupied by the mangrove vegetation, but it is probably shaded out by it."

The determination of the Philippine government to place the manufacture of native drinks on a revenue basis, which determination found expression in an Act approved March 10th, 1917, especially led to investigations of the palms of the islands from an industrial standpoint, including sugar-producing possibilities, by the Philippine Bureau of Science. As a result of these investigations and experiments the bureau has called the attention of the business world to the probability that sugar can be made more economically in the Philippines from the Nipa than from sugar-cane. The sap in its composition so nearly resembles cane juice that no special changes are necessary in the process of refining, and moreover no expense for grinding is necessary, as in the case of cane. The palm juice also has an advantage over the cane juice in that it is free from acids, wax, etc., is colourless, with no debris, and with no invert sugar when fresh. "While the chemical side of the question has been fairly settled," says Perkins, "the labour problem and that of the yield obtainable from any given swamp can be settled only by trial."

The Nipa offers many distinct advantages as a sugar producer over other palms in the Philippines, as for instance, the swamps exist and are ready to be brought into actual production merely by thinning; the tree is extensively grown in localities that would otherwise remain waste land; the numerous water-ways offer cheap transportation for the juice to the mill; and owing to the nature of the plant, the flower stalk being close to the ground, the sap can be easily and quickly collected, and moreover the plants reproduce themselves.

"Since the cost of refining will probably be less than that for cane, and since sugar is an expensive raw material for the manufacture of alcohol," says Gibbs, "I am strongly of the opinion that more profit is to be made from Nipa lands through the establishment of sugar refineries than distilleries." The methods and plants in use for handling cane juice, with slight modifications, are adapted to the handling of Nipa sap.

Methods of Obtaining the Sap.—The tree is tapped the fourth or fifth year after planting the seed. Some time after the fruit has formed the stalk is cut across near the top, usually just below the fruit, and each day a thin slice is removed. In case the plant bears two fruit stalks the usual practice is to draw sap from one only, the other being removed and the stem allowed to dry up. According to a native superstition in the Philippines, the stalk must be kicked in passing once a week for five weeks before it is cut and before the sap will flow freely. In some localities this is done three times a week for five weeks. In reality this is a means of bending down the flower stalk so that the sap may be collected easily. The general practice is to shake the stem gently for fourteen mornings, after which the sap begins to trickle out.

The sap is collected in bamboo joints hung upon the stem. Before these receptacles are used they are usually coated on the inside with milk of lime by dipping them into a rather thick mixture of lime and water. This coating keeps the sap in an unchanged condition for more than ten hours. "Since this preservative enables the sap to be collected and transported to the central refinery in an unchanged condition," says Gibbs, "the principal difficulties connected with such an industry are met, for

the sap in its composition so nearly resembles cane juice that no special changes are necessary in the process of refining." "The chief difficulty in utilizing Nipa as a source of sugar," according to Brown and Merrill "lies in the fact that normally fermentation commences with the flow of sap from the cut peduncle ; that enzymes are present in the sap which will in time cause complete inversion of the sucrose ; and that it is difficult to prevent this inversion. With the use of a modified type of container for gathering the sap, freshly lined with lime cream and sulphite, fermentation and inversion can be prevented or inhibited for at least twelve hours, thus allowing sufficient time to collect and deliver the sap without undue loss of sucrose."

Method of Manufacture.—The following is a description of a sugar-making experiment conducted by the Philippine Bureau of Science commencing December 14, 1910.

At six o'clock in the evening twenty new bamboo joints were coated on the inside with a thick mixture of lime and water and immediately placed in position to catch the sap from as many Nipa palms. The lime employed was manufactured at the distillery by burning oyster and other shells. At six o'clock the next morning the sap which flowed during the twelve hours was collected in a glass demijohn and transported to the laboratory in Manila. It was filtered twenty-eight hours after collection and the clear filtrate measured 15 liters. Four liters of this liquid was heated to boiling in a large porcelain evaporating dish and carbon dioxide run in until the alkalinity was reduced to 0·10 gram calcium oxide for 100 cubic centimeters of solution. The solution was then filtered and analysed. The process of evaporation was then continued and the alkalinity further reduced with sulphur dioxide to 0·011 gram calcium for 100 cc. of liquid. The solution was again filtered and analyzed. This solution contained, according to analysis, 236 grams of sucrose. On boiling down to a massecuite and cooling, crystals of good grain were obtained. These, on drying in a hand centrifuge and finally in an air bath at about 90 degrees, weighed 157 grams, were pure white, and polarized at 96·8 per cent. The molasses and washings were boiled down to a second massecuite and treated in the same way. A yield of 79 grams of very light-yellow sugar, polarizing at 93·8, was obtained. The second molasses was light yellow, measured 20 cc., and polarized at 58·6. A third sugar could easily have been crystallized from it if the volume had been sufficient. The losses were entirely due to the numerous samples taken for analysis and to the handling of small quantities of material in the centrifugal machine.

Yield.—The Nipa begins to yield sap when four or five years old and continues to produce on an average of about fifty years or more. The sap flows about 2½ to 3 months, but the fruit does not all ripen at once, so that the sap-gathering period extends over about six months. According to results of experiments by the Philippine Bureau of Science, the Nipa produces about 40 liters of sap per tree during an average season, and with 750 bearing trees per hectare, which is a conservative estimate, the yield would be about 30,000 liters of juice. About 9,000 liters of the sap is required to produce one metric ton of 96 degree sugar, so that a ten-ton mill running at full capacity would require 90,000 liters of sap daily, and it is estimated that about 450 hectares of good producing swamp would supply such a mill, operating at full capacity, during the height of the season.

"During mill experiments with large quantities of low-grade juice," say investigators of the Philippine Bureau of Science, "we have extracted sugar until the final molasses had an apparent purity of only 50. Since this extraction is at least 10 per cent. greater than the beet-sugar practice it represents a further source of profit. . . . Approximately 115 kilograms of commercial white sugar, polarizing at from 99 to 99·5, can be recovered from 1,000 liters of sap possessing average composition."

The average Nipa sap as it flows from the palm has approximately the following composition :—

Density 15°/15°	1·067
Brix	17·01
Apparent purity	90·0
Invert sugar	Trace
Sucrose	15·0%
Nitrogen	0·049%
Ash	0·60%
Sodium chloride	0·45%

PRODUCTS OTHER THAN SUGAR.

Fruit.—The inside of the fruit when young is edible and is used for food. A good preserve is made from the mature seeds boiled in sugar.

Leaves.—Except in regions remote from the sea the leaves are more commonly used than any other material for thatching the light-construction houses of the Filipinos, and are said to last five to six years on a roof of ½-inch pitch. In Guam they are used for thatching the houses of the better class. They are also used as siding and as such last many years. In addition they are used for making hats, matting, sails, raincoats, coarse baskets, buckets, and bags. The midribs are used in making coarse brooms, for tying bundles of rice, and for sewing Nipa shingles. When burned the foliage yields salt, which is used for various purposes. The pounded leaves are mentioned as a remedy for bites of centipedes and a cure for ulcers. The stalk serves for fuel, while the splints prepared from the cortex are sometimes used for making baskets.

Sap.—According to a tradition of the Filipinos, the properties of the Nipa sap were discovered by an old man while cutting wood for kindling. Accidentally he severed the peduncle of Nipa plant and noticed a clear liquid exuding. Being thirsty he applied his lips to the cut and found the sap to be sweet.

It is probable that the natives of the Philippines fermented beverages from the Nipa sap before the arrival of Europeans in the islands. According to Gibbs, Oliver van Nordt reported that all these islands produced an abundance of wine from Nipa sap, and that nearly three hundred years ago Luischaten mentioned in his *Account of a Voyage to the East Indies* that toddy obtained from the spathes of the Nipa palm yielded an excellent wine.

The great commercial value of the Nipa in the Philippines is its production of alcohol. The extensive investigations and experiments of the Philippine Bureau of Science with palms demonstrated, according to J. F. Boomer, that the Nipa furnishes "the cheapest raw material in the world for the manufacture of alcohol," and that denatured alcohol made from the sap is cheaper than gasolene and fully as effective as fuel for gasolene motors, and that with a motor built for the use of alcohol this fuel would be 20 to 30 per cent. better than gasolene.

The total production of alcohol in the Philippines was estimated in 1915 at approximately 2,500,000 gallons per season. About nine-tenths of this was made from the Nipa palm and in 1913 about seventy-five modern distilleries were engaged in the industry, it being the practice of the distillers to purchase the sap from the natives. Most of it came from one Nipa swamp of about 45,000 acres, only about one-third of which was being worked. It is estimated that the untapped area of the Philippines would yield about 50,000,000 gallons of alcohol for fuel each season. The sap is self-fermenting and ready for the still within a few hours after coming from the plant. The yield of alcohol from the sap is given at from about 4·1 to 7·5 per cent. The alcohol is capable of rectification as high as any alcohol known. It was awarded first prize for chemical purity at the Paris Exposition.

A fermented drink made from the sap and known as *tuba* was highly esteemed by the natives. If allowed to stand six to ten hours the sap becomes vinegar of good quality. Yeast is also made from the sap.

BREEDING ORNAMENTAL HIBISCUS: ARTIFICIAL AND NATURAL SELECTION FOR DWARF, MEDIUM AND TALL SEEDLINGS.

NEMESIO B. MENDIOLA AND JUAN O. UNITE.

of the Department of Agronomy.

A preliminary report was published in 1923 on the ornamental Hibiscus seedlings that were raised in this College about three years ago. These were seedlings of different varieties of *Hibiscus rosasinensis.* No mention was made in that report about dwarf, medium, and tall seedlings, except that these could be grouped as such, and that the dwarfs were believed to be well adapted for pot ornamentals; something new in the Philippines in ornamental hibiscus growing. In the present paper, the authors attempt to bring out the adaptability of the dwarf and medium seedlings for pot cultures and the practical relation of the tall and dwarf types to natural and artificial selection.

By dwarf seedlings, in this article, is meant those seedlings which grew in height so slowly that when at the age of about nine months they began to flower, they were hardly two decimeters (8 inches) tall, while the other types ranged from about a half to one meter in height. In general, the branches in the dwarf forms are produced very close to the ground, the attachment to the stem being scarcely two centimeters above. In the taller varieties the branches are attached to the stem at about one-half meter or more above the ground. Moreover, the leaves of the dwarf varieties are smaller than on the taller seedlings. In size of flowers there is no difference, that is, the size of the flower does not appear to be correlated with the height of the variety. At the age of three years, the dwarf seedlings were about one-half meter or less in height, while the "tall" ones were four times as high and sometimes more. The medium seedlings ranged in height between the dwarf and the tall.

Even very early in the life of the seedlings, when they are five centimeters or less in height, it is possible to distinguish some of the dwarf forms from the taller groups.

NATURAL SELECTION.

When the three types of seedlings were grown together in a plot, the tall individuals, as would be expected, were observed to have the best chance of surviving, while the dwarfs had the least. At the end of three years, most of the dwarf and some of the medium individuals had died, a natural elimination. It should be mentioned here that this observation was made on plants grown 35 centimeters apart each way. The death of the plants was apparently not due to any disease or pest attack on either the roots or the stems and leaves. Those that died just showed lack of vigour at the beginning, then gradual decrease in number of leaves, until finally no life was left. The medium plants which died showed the same symptoms. Not one of the tall seedlings died. The authors are inclined to believe that natural elimination in this case was a matter of lack of adaptation, the dwarf seedlings not being adapted to conditions in which the taller plants thrived to a fair degree. When some of the dwarf hibiscus which appeared almost dead were removed from the plot and placed in 9-inch pots, they subsequently showed even more than their original vigour and flowered constantly, whereas in the plot, they would flower only very occasionally in the period of their decline. The tall hibiscus flowered continuously without being removed from the field of the struggle for existence and such varieties as were adapted to natural seed production produced pods and seed.

Under proper conditions of moisture and temperature the seeds which drop from the ripened pods to the ground germinate and produce new seedlings. This fact indicates that even if some of the dwarf individuals survive in the first generation, in a possible second sexual generation, and in subsequent generations, they will probably be finally eliminated. In the first paper, it was suggested that dwarfness is recessive to tallness. The small number of dwarf hibiscus which are produced compared with the tall and the fact that the dwarfs are naturally eliminated in competition with the tall individuals might account in part for the rareness of the dwarf type. The chance of this type surviving would depend upon its being removed from competition and therefore on its having some ornamental qualities to recommend it for artificial selection.

ARTIFICIAL SELECTION.

A number of the dwarf plants in the College cultures were able to reach their flowering age. It so happened that their flowers were attractive in a number of respects, in shape and colour for example, and as the authors desired to save them for this reason, they were potted and taken where they could be given particular attention. This better care consisted only in watering the plants often enough to keep the soil in the pot moist. They were not even specially fertilized although the soil used to fill the space in the pots came from a place supposedly rich in organic matter. During the dry season, it was necessary to water the plants once a day. Had the plants which died flowered, producing desirable flowers, before they perished, this production of beauty might have led to their being saved by potting and subsequent care.

The results obtained by potting suggest that in a commercial culture of hibiscus seedlings, it would be advisable to separate the dwarf and otherwise weak plants from the taller and more vigorous ones and to grow them under more favourable conditions. Even at the risk of potting plants whose flowers are not especially beautiful, one should not wait for these dwarf plants to flower, as most of them might die before reaching the age of reproduction. No matter if they will produce flowers similar to those of their tall or medium companions, they are worth saving for pot culture purposes. The tall type is very undesirable for growing in pots.

THE DWARF AND MEDIUM HIBISCUS SEEDLINGS AS POT ORNAMENTALS.

In the third year of life of the seedlings the authors cultured some twenty of the dwarfs in pots for a year; so far, none of the plants has died. On the contrary, they appear healthy, healthier than the plants not potted and some of them have produced from one to four flowers most of the time since they began to bloom in the pot. In this year of life in the pot they have grown hardly any taller. All these observations tend to show the adaptability of dwarf hibiscus seedlings for pot cultures.

As potted hibiscus seedlings are almost unknown in the Philippines, especially the dwarf variety, the potted seedlings under report have attracted no little attention from plant lovers. It should be mentioned that floriculturists in Manila occasionally offer potted hibiscus for sale, but these are of the tall, native variety, and their tall lanky appearance do not make them attractive pot ornamentals. On the other hand, the dwarf varieties, such as those grown in this study, have the short stature and compact growth which one is apt to look for in a potted plant. The tall varieties in the pot do not produce as many branches as the dwarf and therefore they do not produce flowers as frequently and in such abundance. An interesting characteristic of some of these dwarf plants is their occasional production of miniature flowers which are not distorted like those attacked by insects at their bud stage but which are perfectly normal except as to size. Another interesting habit shown by some hibiscus plants of not only the dwarf, but also of the medium and tall types, is that the shade of colour in the flower changes slightly as the plants become older. One change was from light yellow to deeper yellow. It would be interesting and of commercial importance to determine how much of the dwarfness exhibited by first generation seedlings is transmissible to first and subsequent generations of plants raised by cuttings or by other vegetative means. It is only to be suspected that this dwarfing is hereditary. However, it may also be possible that this dwarfing came about partly as a result of stunting influences exerted by the environment on the plants when they were very small, much smaller than any young plant that generally can be grown from cuttings.

The seedlings which are intermediate in height between the dwarf and the tall types may be grown in pots also, although they thrive under less care than the dwarf varieties. If these larger types are potted, pots larger than 9-inch pots should be used. Grown alone, these medium seedlings do not present as beautiful and as attractive an appearance as the dwarf kinds, not that they produce fewer flowers, but they seem fewer

because of the larger size of the plant. However, potted medium tall plants properly placed among potted dwarf plants, produce a very attractive combination, being less monotonous than a group composed wholly of dwarf varieties.

A word or two may be added in favour of ornamental hibiscus plants as compared with other flowering plants. As hibiscus blooms only for a day (varieties which bloom for two or more days are known but are rare) and new flowers are produced constantly, there is in the hibiscus a daily freshness which is not found in flowers which last for several days : as for example, roses. Then also, if one has ten, twenty, or more hibiscus plants of different flower colours, he is likely to get a different combination of colours every day. One day, he may have white-yellow-rose combination, another day he may have the pink-near-blue orange colour grouping. One shortcoming of the hibiscus flowers is their lack of fragrance. But there are fragrant varieties. In fact, in the authors' cultures, there is a variety with a fair amount of sweet odour in the flower, and it may be that as a result of natural selection or artificial efforts a variety as fragrant as the rose may yet be evolved.—The Philippine Agriculturist, Vol. XIII, No. 1.

ILLIPI NUTS.

E. M. HOLMES, F. L. S.

Some kernels have recently appeared in the London market under the above name, which the drug brokers evidently did not take the trouble to have examined, for they are not the kernels properly so named. The word illipi, illupei or illupai is correctly applied to various species of *Bassia*, those of *Bassia longifolia*, L., being called illipi, those of *B. latifolia* Roxb., illupei or illupai, and those of *B. malabararica*, Bedd., att-illupei, in the different provinces of India where they occur. These have been largely imported for the expression of fat for soap and candle manufacture, and as much as £64,922 worth was imported into this country in 1907-1908. In 1907 Belgium imported into Antwerp illipi nuts to the value of £140,661. In this country these seeds are imported chiefly into Liverpool, and are so little known in the London market that when ten tons were offered by Lewis & Peat on February 9, 1911, at the drug auction in London, no bid was made, no one appearing to know their use or value.

The *Bassia longifolia* grows not only in Southern India but in the Malay States, but as other fatty seeds are also exported from Singapore the others are sometimes confused with the true illipi "nuts" or seeds. An illustrated article dealing with the true illipi seeds was given in the *Chemist and Druggist*, March 4, 1911, pp. 89-90. The whole seed is there represented. The description given of it is not quite accurate when it is stated that the shell is smooth and bright, but it may be much wrinkled, and that frequently "the outer portion of the shell has been rubbed off, thus exposing the dull inner portion". As a matter of fact, it is a characteristic feature of seeds of the natural order *Sapotaceae* to have about two-thirds of the surface polished and smooth and the other one-third rough. The roughness is natural, not brought about by rubbing.

Most of the trees of the *Sapotaceæ*, to which natural order *Bassia* belongs, have a substance like gutta-percha present in the fat they contain, which unfits the fat for many economic purposes, and they soon become rancid as a rule, but are a cheap material for soap and candle manufacture. But the so-called illipi nuts in the London market at the present time differ distinctly from the true illipi nuts. The kernels of the latter split into two smooth often concave halves, like an almond, but the so-called "illipi" nuts split into four parts, having a *projection* and a meeting in the vertical furrow *in the centre of each*. This is characteristic of the family of *Dipterocarpaceæ*, to which family the so-called illipi nuts in London in 1924 obviously belong. They are the broken seeds of various species of *Hopea*, *Shorea*, *Isoptera* and other genera of *Dipterocarpaceous* trees native in Borneo, from which the fat is extracted and used by the natives, and exported to a certain extent to Singapore. It is known as Minjak Tangkawang in Borneo, and as Borneo tallow in Ceylon, and vegetable tallow from Singapore when it comes to London.

This fat is mentioned as long ago as 1882 in *Spon's Encyclopædia* Vol. II, p. 1413, and is said to be obtained from probably about ten different trees belonging to the genus *Hopea*. In 1883 Mr. H. Jamie, then residing at Singapore, presented to the museum of the Pharmaceutical Society in London several of the different qualities of this vegetable tallow, and remarked concerning them that the fat never turns rancid, and when the white kind is got, which is seldom, it makes very good ointment simply with the addition of olive-oil. At the ordinary temperature this tallow is a white friable solid, softening when rubbed between the fingers and ultimately melting sufficiently to be rubbed in without leaving the hand very greasy. This fat in 1883, at my request, was made the subject of a few preliminary experiments by Mr. Edward Fielding (Y.B. Pharm., 1884 p. 248), who found that at 65°F. it remains a little solid, between 82° and 104°F. it has the consistence of flour paste, at 108°F. it fuses, but remains transparent and liquid at 112°F. Very soluble in acetone when heated, but is mostly precipitated on cooling, and in cold benzene in about 1 in 4: in hot benzene or petroleum spirit (hexane or heptane) in all proportions, but the solution gelatinises when cold, also in cold turpentine and when heated, in all proportions.

My attention has recently been called by the Editor of the *Chemist and Druggist* to a statement made by the West India Committee and published in the *Ceylon Observer* that upwards of 1,000 tons of a substitute for cacao butter were being imported annually into England and used in the manufacture of chocolate, with the result that no less than nine million pounds of cacao beans are thereby displaced which would otherwise be used for their manufacture. The chief of the adulterants used are coconut-butter and what is called Borneo tallow. More than twenty years ago, not long after the introduction of the "vegetable tallow from Singapore," which is really a product imported there from Borneo, I was asked by a firm in the City of London if I knew of any fat that melted about the temperature of cacao-butter, and which could replace it in making the chocolate creams, *the price* of cacao butter having risen *so as to make its use impracticable*, while coconut-fat was too soft and soon became rancid.

I suggested a trial of the Minjak Tangkawang, which had very slight flavour, melted slowly in the mouth, did not readily become rancid, and approached more nearly in consistence to cacao-butter. The late Dr. B. H. Paul kindly examined a museum specimen and reported to me that it would answer admirably as a substitute for a cacao-butter if it could be entirely deprived of a faint flavour, which he did not succeed in doing. But that was before the days when it was discovered how to entirely free cod-liver oil, castor-oil, and coconut-oil, etc., from all flavour. Presumably this had since been done, and this is the Borneo tallow to which the writer in the *Ceylon Observer* refers.

But it is a product that would well deserve the attention of colonists in tropical countries where there is suitable hilly ground near rivers, especially the large fruited tree which yields the variety known as *Tangkawang toengkoel*, which is derived from *Shorea stenoptera* according to Dr. Burck, and from *Hopea splendida* according to Dr. Vries. This is the only species cultivated by the natives, although the fat is derived from several other species growing wild in the forests. The *Shorea stenoptera* is described by Dr. Burck as yielding the largest fruit of any of the Tangkawang trees, being six centimetres long by four broad. The tree flowers in September and October and the fruit ripens in February and March. It differs from the allied species in the wings of the calyx being hardly longer than the fruit and not more than ½ cm. broad. It grows in the province of Sintang in N.W. Borneo. It is a large tree, the trunk sometimes attaining a metre in diameter.

An excellent account of the cultivation of the tree and of the native method of extracting the fat is given by Mr. H. B. Bakker, of Sangan (Ph. Jour. (3), xv pp. 407-428). Most of the Tangkawang trees prefer the banks of rivers and rivulets, especially where loam is mixed with sand and the soil humid. They can bear up against a short inundation, but one of long standing is fatal to them. The seeds germinate, when ripe, in about fourteen days. They are grown as follows: a piece of bamboo, 0·2 to 0·3 metres in length, is filled with earth, and the fruit put upon this very soon begins to shoot, and in three or four months the stem has already attained a height of about half a metre and has formed three or four leaves. Then the remains of the fruit pulp are removed and the bamboo with the plant in it is planted in the ground at intervals of about 6 ft. to 12 ft. which however, is insufficient, but the grower removes the less vigorous plants The fruit crop is usually fully four years after planting, but it may be eight or even twelve years. The yield of one tree is estimated at a value of 1·5 to 4 dollars, and in exceptionally favourable cases even 11 dollars.

The broken seeds or paddi as they appear in the London market are evidently, from their shape and size, the mixed product of different trees, and it is evident that the percentage of fat obtainable will depend upon the proportions of the different kinds in the paddi. For edible purposes, or the manufacture of margarine or confectionery, it is evident that a pure paddi of the *Tangkawang Toengkoel* should be used to extract the fat. This is probably the kind mentioned by Mr. R. Jamie as the white fat which is presumably kept for home consumption as much as possible, and therefore the cultivation of this kind, *Shorea stenoptera*, Burck, or *Hopea splendida*, De Vries, is the one that should receive attention. The fruits of *Shorea stenoptera* are stated to yield about 50 per cent. of fat.—The Chemist and Druggist, Vol. CI, No. 2327.

THE HABIT OF BUDDED CACAO.

PROFESSOR S. C. HARLAND, D.Sc. (LOND.)
and
R. G. PARGA, B. A. (OXON.).

One of the most striking features of the plots of budded cacao at the River Estate of the Trinidad Department of Agriculture, is the low, spreading habit of the trees, and the absence of the chupon or water-sucker type of branch. As is well known, the cacao tree grown from seed has two kinds of branches, which differ in the arrangement of their leaves: these are respectively the main axis type or chupon, and the fan or palm type. A young cacao seedling produces first a vigorous main axis, which sooner or later divides into five branches, known in Trinidad as the "jorquette."

The main axis can be carried on by a bud which arises on the main stem just below the jorquette. This grows upward and after a time divides into about five branches as before.

This method of growth can be repeated until a three or even "four storied" tree is formed. A tree with more than one "story" is much favoured by some planters, while others prevent the tree from making more than one jorquette. The five branches into which the main axis terminated are of the fan or palm type.

The cacao tree is thus dimorphic in its branching system, and the two kinds of branches, chupon and fan respectively, possess a different arrangement of the leaves. The chupon has leaves arranged round it according to the formula $\frac{3}{8}$, that is if one looks at two leaves, one immediately above the other, a spiral round the stem can be traced, the spiral going three times round the stem, and passing seven leaves in its course. The fan branches have apparently the formula $\frac{1}{2}$, that is the leaves are arranged alternately on different sides of the branch.

In the adult tree chupon branches often arise from below the jorquette, and may also arise upon the side branches, or secondary side branches, but this latter case is somewhat rare.

Fans have no definite termination, but at the end of each season's growth the terminal bud becomes dormant, again growing out the next season. Chupons, however, invariably terminate in the usual five branches, all of which behave as fans.

Returning to the habit of budded cacao, it will be noted that the branching habit is not dimorphic, but monomorphic, the only kind of branch produced being the fan. The two-storied tree favoured by some planters is thus impossible with ordinary budded cacao, and equally impossible is the main axis jorquette type. The writer has examined large numbers of budded trees and only on one occasion has the presence of a chupon branch been noted.

The above series of facts led us to consider whether the prevailing habit of budded cacao is due to the type of bud used for budding, and on enquiry it was found that buds are invariably taken from fans, and not from chupons. Without going any further then, the conclusion is obvious that monomorphic (fan) trees result from the use of buds from fans. Since

a bud in the dormant state is already fully differentiated, a simple way of finding out what it will develop into is to make it sprout by cutting off the whole of the branch immediately above it, and an extensive series of pruning experiments have been carried out on both fans and chupons. The object of the experiments was to determine under what conditions, if any, a dimorphic type of budded cacao could be produced, *i.e.*, a budded cacao with the same habit as seedling cacao.

Summary of the Experiments.—(1) Fans when pruned back generally produce fans from the topmost bud and any others which develop, (2) In certain circumstances fans can produce chupons. Out of 59 pruned fans, 57 gave fans, and 2, both from the same tree, gave chupons. (3) Chupons generally give chupons after being pruned back. Out of 40 prunings, 24 gave rise to chupons, and 9 to fans; the rest remained dormant. There is some doubt as to whether the chupons which produce fans were really chupons, for some branches when young may appear to have a chupon leaf arrangement and afterwards turn out to be fans. On close examination of the chupons which gave fans it was concluded that there was no clear case of a chupon which had already forked producing a fan after being pruned below the fork. Further experimeuts on this point, however, are in progress, and it must be strongly emphasized that any one who desires to find out whether chupons can form fans, should make use only of chupons which have already forked.

Discussion.—From the results of pruning experiments it is clear that if buds for budding are taken from chupons instead of fans, an entirely different sort of tree will result, resembling the seedling in habit. This should be termed dimorphic budded cacao, to distinguish it from the ordinary type. Which of the two types is agriculturally the better should now be the subject of experiment, but even in the present state of knowledge it is possible for a planter to grow budded trees of the habit which he prefers.—Tropical Agriculture, Vol. I, No. 9.

A NEW USE FOR CACAO.

In times of over-production of an agricultural product or of low prices and sluggish market, the development of new ways of using up material has often proved of great help to the industry. The investigations along this line by the rubber industries since 1913, have been fruitful of results. For several years now the cacao market has been depressed and it would appear that a possible new use for cacao, which may in the future considerably increase its consumption, has been found in the development of cacao bread. The United States Department of Agriculture carried out experiments which resulted in a bread being prepared in which from 8 to 10 per cent. of the flour used was substituted by cacao powder, and the shortening usually supplied was omitted, as this is supplied by the cacao, presumably by the fat which it contains. This bread has now been manufactured in Trinidad according to the United States' recipe and has been pronounced by many who have tried it to be very palatable and likely to meet with some demand. If such a demand became general the consumption of cacao might be increased.—Tropical Agriculture. Vol. I, No. 10.

MARKET RATES.

MARKET RATES FOR SOME CEYLON PRODUCTS.

(FROM THE CEYLON CHAMBER OF COMMERCE WEEKLY PRICE CURRENT, DATED 13th OCTOBER, 1924.)

NAME OF PRODUCE	CURRENT PRICE			REMARKS
	Rs. cts.	at	Rs. cts.	
CACAO—(At Buyer's Stores)				
Estate—Finest ... ... per cwt.	50 00	,,	55 00	
Do Medium ... ... do	38 00	,,	40 00	
Do Common (Black) ... ... do	10 00	,,	15 00	
CARDAMOMS				
All round parcel well bleached ... ... per lb.	... ...	,,	... ...	
Do do medium ... ... do	... ...	,,	... ...	
Special assortment 0 & 1 only ... ... do	... ...	,,	... ...	
Seeds ... ... do	... ...	,,	... ...	
Green ... ... do	2 75	,,	3 11	(Nominal)
CINNAMON QUILLS—(At Buyer's Stores)				
Ordinary assortment (in bales of 100 lb. nett) ... ... per lb.	0 82	,,	0 92	
No. 1 ... ... do	0 85	,,	0 94	
No. 2 ... ... do	0 83	,,	0 92	
No. 3 ... ... do	0 79	,,	0 90	
No. 4 ... ... do	0 74	,,	0 86	
CINNAMON CHIPS—Maradana, (At Buyer's Stores) (in bags of 56 lb. nett) per candy of 560 lb.	75 00	,,	90 00	
CITRONELLA OIL—(ex-Seller's Stores without packages) ... per lb.	1 67	,,	1 80	
COCONUT—(Desiccated) Granulated goods (Delivered at Wharf or Buyer's Stores)				
Assortment: Medium 50 per cent. Fine 50 per cent. ... per lb.	0 20½	,,	0 21½	
COCONUT OIL—				
White Oil f.o.b ... ... per ton	... ...	,,	... ... 555 00	
Ordinary Oil do ... ... do	... ...	,,		
COPRA—				
No. 1 quality per candy of 560 lb.	81 00	,,	85 50	
Calpentyn ,, ,,				
Estate ,, ,,				
Ordinary quality (Maravila) ,,				
Cart Do do ,,				
FIBRES—(At Buyer's Stores)				
Coconut Bristle No. 1 ... ... per cwt.	... ...	,,	10 00	
Do No. 2 ... ... do				
Coconut Mattress No. 1 ... ... do	... ...	,,	3 35	
Do No. 2 ... ... do				
Coir yarn, Kogalla Nos. 4 to 9 ... ... do	12 00	,,	25 00	
Do Colombo Nos. 3 to 7 ... ... do				

PLUMBAGO	X. B.				B				B. E.			
	Rs. cts.		Rs. cts.		Rs. cts.		Rs. cts.		Rs. cts.		Rs. cts.	
Ordinary Lumps ... ... per ton	300 00	at	325 00		250 ...	at	275 00		175 00	at	200 00	
Chips ... ... do	250 00	,,	275 00		... ..	,,	200 00		140 00	,,	160 00	
Dust ... ... do	175 00	,,	200 00		... ...	,,	125 00		75 00	,,	90 00	
Do Flying ... ... do	80 00	,,	145 00		75 00	,,	80 00		30 00	,,	60 00	

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31st OCTOBER, 1924.

Province, &c.	Disease	No. of Cases up to date since Jan 1st, 1924	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	1198	70	455	721	5	17
	Foot-and-mouth disease	1931	73	1897	19	15	—
	Anthrax	7	—	—	7	—	—
	Hæmorrhagic Septicæmia	6	—	2	4	—	—
	Rabies	1	—	—	—	—	1
Colombo Municipality	Rinderpest	1214	143	*			
	Foot-and mouth disease	154	3				
	Anthrax	—	—				
	Rabies	2	—				—
Cattle Quarantine Station	Rinderpest	10	—				
	Foot-and-mouth disease	27	—				
	Anthrax	181†	20				
	Pleuro-Pneumonia (in goats)	115	—				
Central	Rabies (Dogs)	13	—	—	13	—	—
	Foot-and-mouth disease	931‡	129	834	16	81	—
	Anthrax	8	—	—	8	—	—
	Hæmorrhagic Septicæmia	1	—	—	1	—	—
	Piroplasmosis	4	—	4	—	—	—
	Mange (in Buffaloes)	6	—	6	—	—	—
Southern	Rinderpest	153	23	44	106	3	—
	Foot-and-mouth disease	2	—	2	—	—	—
	Anthrax	—	—	—	—	—	—
Northern	Rinderpest	—	—	—	—	—	—
	Foot-and-mouth disease	—	—	—	—	—	—
	Anthrax	—	—	—	—	—	—
	Hæmorrhagic Septicæmia	98§	—	3	95	—	—
Eastern	Rinderpest	—	—	—	—	—	—
	Foot-and-mouth disease	9	—	9	—	—	—
	Anthrax	—	—	—	—	—	—
North-Western	Rinderpest	338	20	126	198	—	14
	Foot-and-mouth disease	1302	36	1293	5	3	1
	Anthrax	12‖	—	—	12	—	—
	Rabies (Dogs)	2	—	—	—	—	2
North-Central	Rinderpest	—	—	—	—	—	—
	Foot-and-mouth disease	157	27	145	—	12	—
	Anthrax	—	—	—	—	—	—
Uva	Rinderpest	—	—	—	—	—	—
	Foot-and-mouth disease	9	9	1	—	8	—
	Anthrax	3	—	—	3	—	—
	Black Quarter	26	—	—	26	—	—
Sabaragamuwa	Rinderpest	35	3	4	25	—	6
	Foot-and-mouth disease	2295	346	2216	5	74	—
	Anthrax	12	—	—	12	—	—
	Hæmorrhagic Septicæmia	17	—	—	17	—	—
	Rabies (Dogs)	2	—	—	1	—	1

* Up to end of September.
† 2 cases amongst cattle, the rest amongst goats.
‡ 39 cases mouth disease in goats.
§ 23 cases amongst goats. ‖ 1 dog

M. CRAWFORD,
Acting Government Veterinary Surgeon.

Colombo, 4th November, 1924.

METEOROLOGICAL
OCTOBER, 1924.

Station	Temperature: Mean Daily Shade	Temperature: Difference from Average	Mean Humidity	Mean amount of Cloud 0=clear 10=overcast	Mean Wind Direction during Month	Daily Mean Velocity	Rainfall: Amount	Rainfall: No. of Rainy Days	Rainfall: Difference from Average
	°	°	%			Miles	Inches		Inches
Colombo Observatory	80·6	+0·4	82	7·0	SW	112	14·50	18	+ 1·50
Puttalam	80 8	0	79	4·7	SW	201	7·42	11	— 1·56
Mannar	83·0	+0·6	76	6·2	SW	194	4·48	9	— 3·47
Jaffna	82·0	+0·4	77	5·4	SW	229	9·74	9	+ 0·28
Trincomalee	83·0	+0·5	71	5·0	WSW	201	4 50	9	— 3·78
Batticaloa	81·8	+0·2	71	4·0	Var:	134	6·51	8	+ 0·07
Hambantota	80·2	—0·2	82	4·2	SW	295	6·73	11	+ 1·92
Galle	79·4	—0·2	84	5·8	W	216	10·27	17	— 3·02
Ratnapura	80·6	+0·6	80	6·0	—	—	8 10	21	+10·75
Anu'pura	81·2	—0 2	76	5·5	—	—	8·45	11	— 1·42
Kurunegala	80·3	+0·1	78	7·0	—	—	11·80	17	— 3·88
Kandy	76·1	+0·3	80	7·3	—	—	9·50	18	— 2·30
Badulla	73·6	—0·7	78	5·2	—	—	9·46	14	— 0·42
Diyatalawa	68·2	—0·2	74	6·4	—	—	6·70	17	— 3·92
Hakgala	60·8	0	84	7·5	—	—	13·71	17	+ 1·41
N.' Eliya	59·9	+0·3	82	7·6	—	—	9 30	18	— 1·83

For the first half of October, South-west monsoon conditions prevailed over Ceylon. Till the 3rd there was fairly heavy rain, probably due to the effect on the monsoon of a depression in the Bay of Bengal. After that, however, the monsoon seemed to reach stability, and there was but little rain till after the middle of the month, when the monsoon disappeared It was succeeded by a short spell of inter-monsoon conditions, the mornings at Colombo being clear, and the clouds gradually spreading outwards from the hills during the afternoon, frequently bringing local rains and thunderstorms. Towards the end of the month, the weather became unsettled, and suggestive of the neighbourhood of a cyclonic depression. The barometer, however showed no signs of any depression near us. Dull, overcast skies were the rule, and heavy rains were experienced at all hours of the day.

Rainfall this month was nearly everywhere in deficit. Temperature was nowhere far removed from normal. The height of the barometer, too, was generally about the average. The strength of the wind was above normal, the prevailing direction for the first half of the month being SW, while after that, as might be expected with the passing of the monsoon wind directions were variable. Cloud was, on the whole, about normal, and the humidity varied from about 70 per cent. in the north-east to over 80 per cent. in the south-west of the island.

H. JAMESON,
Acting Supdt., Observatory